Correlation of Volcanism with geomagnetic-changes (solar storms & N-Pole shift) - List of geomagnetic storms 1800-2023

This is Part 3 of my Hypothesis which concentrates on Geomagnetic- (Solar)-Storms & Volcanism → Please also read : Part 1 (Part 1e) & Part 2

by **Harry K. Hahn** / Germany - **20.10.2023** - **Note :** This document is not allowed for commercial use !!

Abstract :

Changes in Earth's Magnetic Field seem to be a main cause of Volcanic-Eruptions on Earth ! These changes (or disturbances) in Earth's Magnetic-Field can be caused either by internal processes which take place near the Core-Mantle-Boundary (CMB), or they can be caused by external events which are strong geo-magnetic-storms caused by solar wind (space-weather). The maximum impact of the external events (geo-magnetic storms) seems to be around +/-20%, and the impact of internal-effects seems to be around +/-30%. As internal effect the North-Magnetic Pole Shift must be mentioned, which showed a very high acceleration between 1993 and 2002.

The internal processes inside Earth's mantle which caused this fast shift of the North-Magnetic-Pole seem to be responsible for an increase of ~30% of Earth's Volcanism between 1997 & 2008. → see my Study Part 2 which describes the internal effects in more detail, that cause the North-Magnetic-Pole Shift and other geomagnetic changes.

In this paper I want to describe the impact of the external events, the impact of strong geo-magnetic Storms, on Earth's Volcanic Activity.

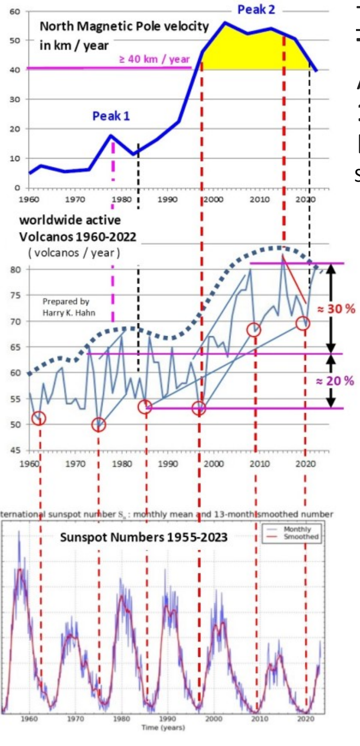
The chart of –**Total Volcanic Eruptions per year**- and -**Strong Geomagnetic-Storms**- in the time **1800-2023** clearly shows that there are sharp increases in the number of volcanic-eruptions visible, shortly after the occurence of strong geomagnetic-storms (or -storm-periods). (This study contains a list of geomagnetic storm datas from 1800-2023)

Further there is a clearly visible **correlation of sunspot-(solar-cycle)-minimas** and **Lows in the chart of the** -**Active Volcanos per year**- which shows that Earth's Volcanism is clearly influenced by strong geomagnetic-storm-periods, or by the missing of such storm-periods ! During sunspot-minimas global volcanism clearly decreases be around 20% !

There is also a clear correlation of Global Volcanism (which is strongly effected by geomagnetic effects), with HGFA-seismicity and Global Warming !

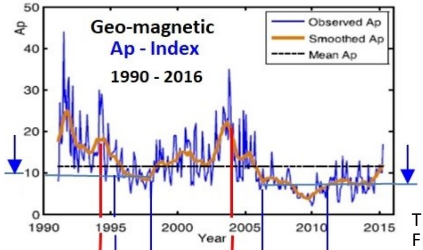
This correlation works in such a way that first the geomagnetic-storms (-changes) seem to increase seismicity (cause more earthquakes), especially in the High-Geothermal-Flux-(HGF)-areas (e.g. mid-ocean-ridges etc.), then with a delay of 1-2 years Volcanism (& hydrothermal-activity, mainly in submarine-areas) is increasing, which then rises the Ocean-Heat-Content (El-Nino-events are the manifestation of this processes), and eventually accelerates Global-Warming !

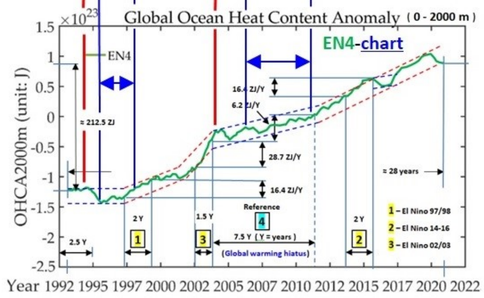
Global Volcanism is correlated with the North-Magnetic Pole-shift & Solar Cycles

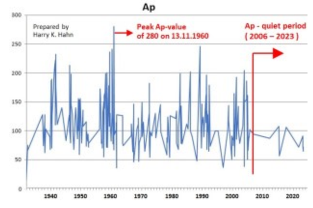


WARNING to Climatologists & Politicians !! : There is clear indication that you will get caught off on the wrong foot soon ! The sun has considerably reduced its solarwind-activity ! Since 2006 only two days with AP-values slightly >100 occured !! The sun is heating towards an extended solar minimum with considerable lower sunspot numbers & solarwind activity !! **This means a general colder climate on Earth** as historical climate-data from the Dalton- & Maunder-Minimum clearly show. A look at the **Ocean Heat Content Chart** (EN4) and the **Geo-magnetic Ap-Index** clearly shows that **during the periods 1995-97** & **2006-2012 the Ocean Heat Content (0-2000m) was stagnating !!** That means global warming nearly stopped !! During these periods the smoothed **Ap-Index was ≤10**, which means very low solarwind-activity !! That's why the impact of geomagnetic-changes (-storms) on Earth's Climate is clearly higher than that of CO2 ! It's a deciding factor ! That's why we must predict the future Solar-Activity !!

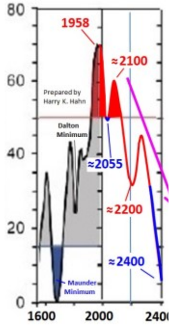
Stagnation of the Ocean-Heat-Content for **Ap-Index ≤ 10**



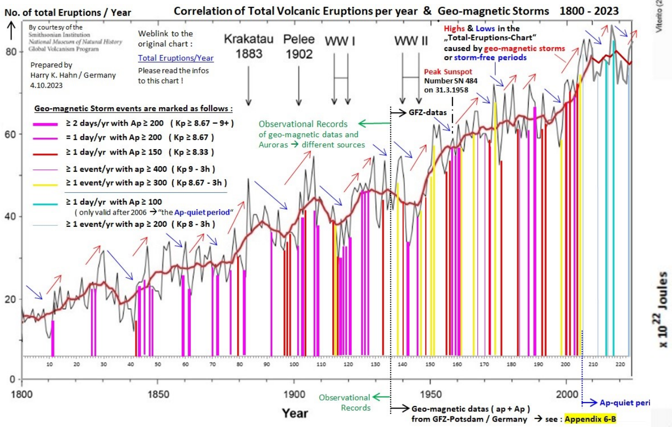




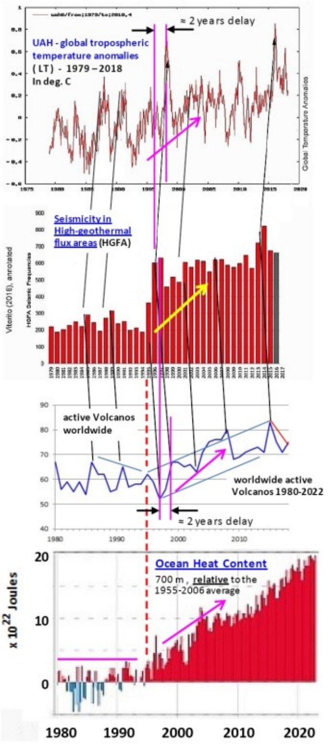
The image below shows my prediction for the Future Solar Activity :



Correlation of Total Volcanic Eruptions with strong Geomagnetic storm-periods between 1800 and 2023. Eruptions rise sharply 1-2yr after geomagnetic storms



Volcanism correlates with seismicity in HGF-areas and Global Warming



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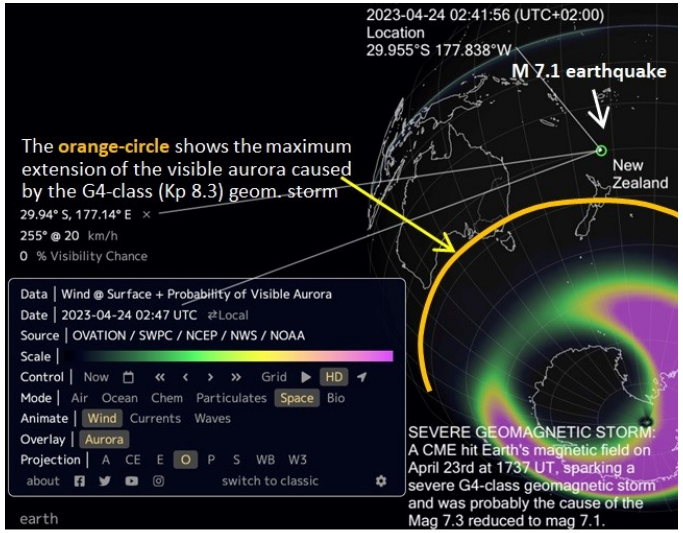
Aurora Australis caused by the geomagn. storm on 23-4-2023 in South-Australia

The **map** on the right shows the **aurora australis** caused by a **G4-geomagnetic storm on 23.4.2023** and the location of the strong **M 7.1 earthquake** that occured **≈7 hours after the start of the G4-storm** in the **Kermadec-Arc**.

Note : **The probability for such a ≥ M7 earthquake** in this 8h-period **was only 1 : 180 !**

This indicates that the earthquake was caused by the G4-geom. Storm

Note : The **Kermadec Arc** is a highly active submarine volcanic area which is located in a **HGF**-area !



2023-04-24 02:41:56 (UTC+02:00)
Location
29.955°S 177.838°W

The orange-circle shows the maximum extension of the visible aurora caused by the G4-class (Kp 8.3) geom. storm

29.94° S, 177.14° E
255° @ 20 km/h
0 % Visibility Chance

Data | Wind @ Surface + Probability of Visible Aurora
Date | 2023-04-24 02:47 UTC
Source | OVATION / SWPC / NCEP / NWS / NOAA
Mode | Space
Animate | Wind
Overlay | Aurora
Projection | O

SEVERE GEOMAGNETIC STORM: A CME hit Earth's magnetic field on April 23rd at 1737 UT, sparking a severe G4-class geomagnetic storm and was probably the cause of the Mag 7.3 reduced to mag 7.1.

M 7.1 earthquake
New Zealand
⇄Local
Scale
Control | Now « ‹ › » Grid HD
Mode | Air Ocean Chem Particulates Space Bio
Animate | Wind Currents Waves
Projection | A CE E O P S WB W3
about
switch to classic
earth

1 - Correlation of -Total Volcanic Eruptions per year- with -strong Geo-magnetic Storms- in the time-period 1800 - 2023

Explanation to this Chart :

1.) To the visible correlation :

There is a clear correlation visible in the chart, of **sharp rises (highs)** in the **"Total Volcanic Eruptions"** with the **occurence of strong geomagnetic storms** (solar storms) indicated by colored lines under the chart.

Shortly after the occurence of a strong geomagnetic storm (period) ,or with a delay of 1-2 years, there is a sharp increase in the number of volcanic eruptions visible ! (Highs)
(indicated by red arrows) ↗

On the other hand there is a clear correlation visible in the chart of decline-periods (lows) in the chart, which correlate with phases where no or very less geo-magnetic storms occured.
(indicated by blue arrows) ↘

This correlation is strong and clearly visible in the chart !

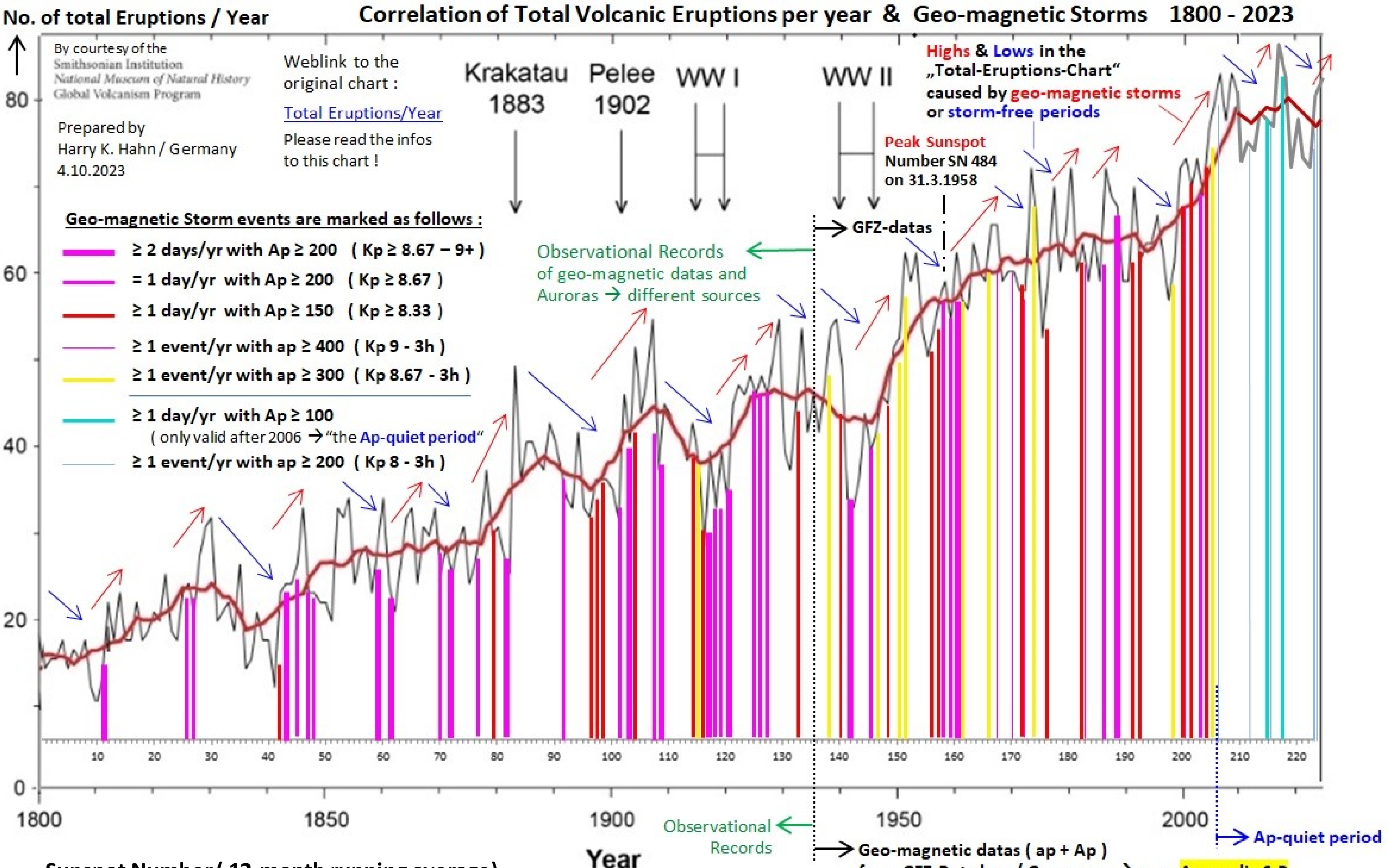
Note : Because the geo-magnetic storms first trigger earthquakes, and with a certain delay of up to ≈1-2 years the volcanic eruptions follow, the rises (peaks) follow with a slight delay after the geo-magnetic storms (storm periods)

2.) Geo-magnetic storm datas :

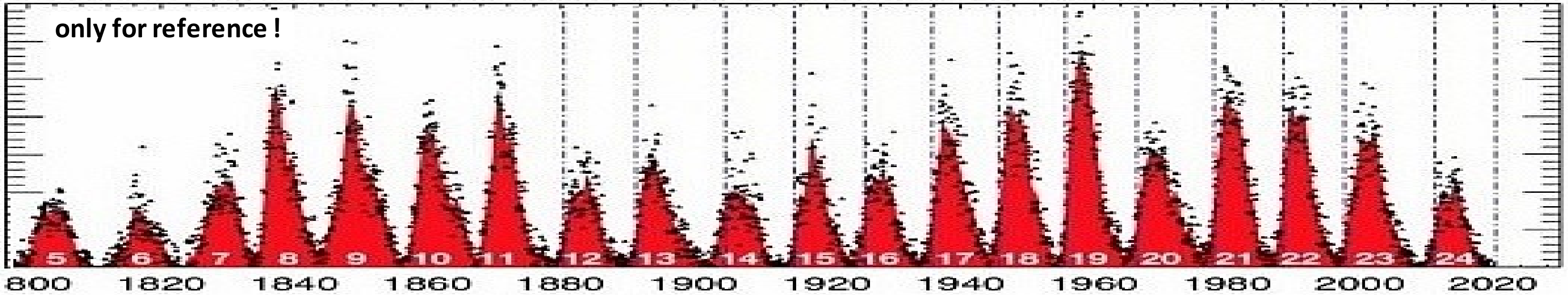
→ see **Tables 6B & 6C** in Appendix

3.) Volcanic Eruptions datas :

→ see **Table 6A** in the **Appendix**
→ Also read the informations of the **Smithsonian Institution !**
see : Total Eruptions/Year



Sunspot Number (12-month running average)

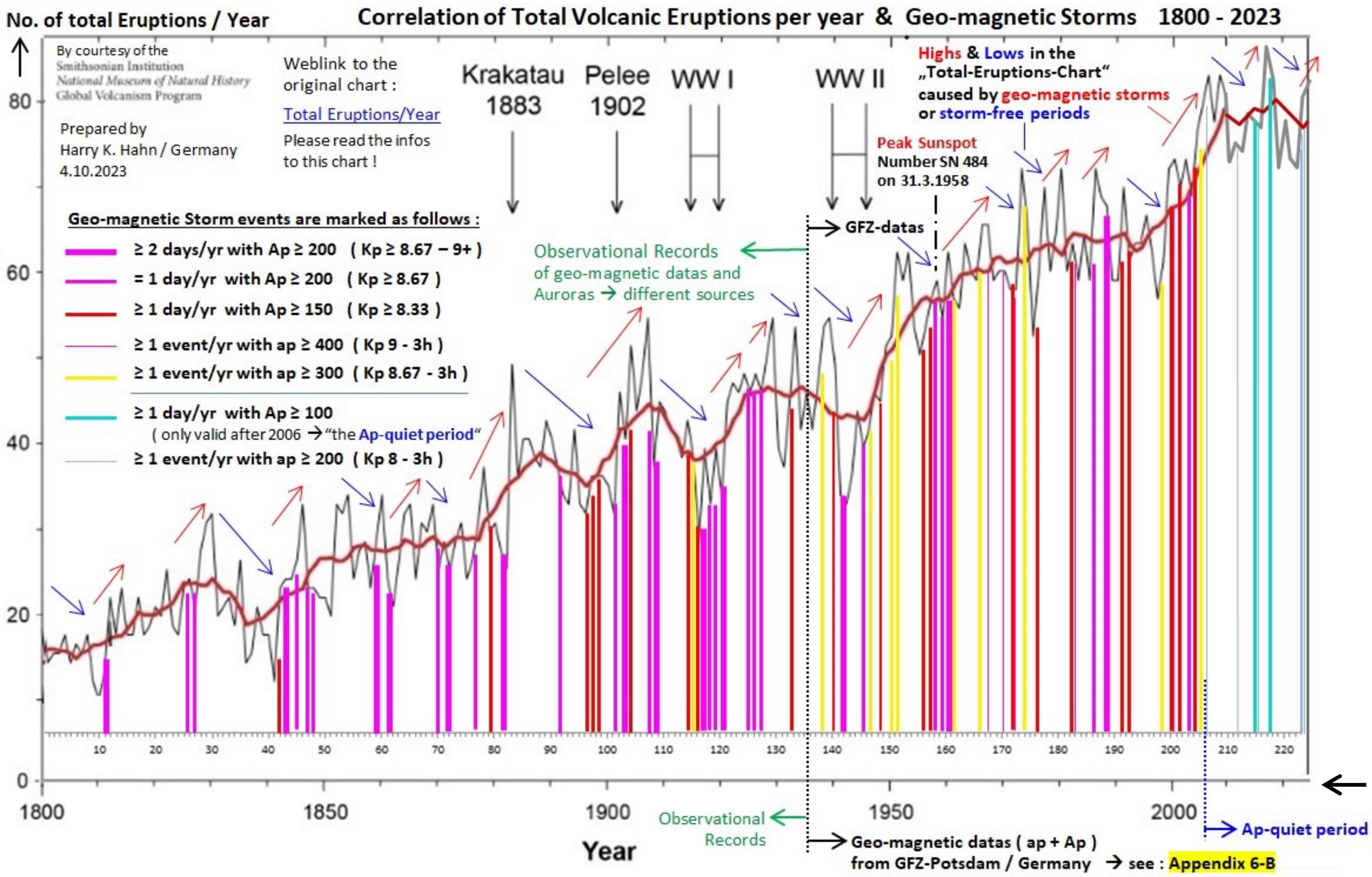


2 - Strong Geo-magnetic storms caused by solar-wind (space weather), cause periods of increased Volcanism on Earth

How does this correlation work ? :

The currents generated by solar winds in the ionosphere cause magnetic-field- fluctuations on the Earth's surface, inducing electrical currents (telluric currents), which penetrate deep into the Earth, and in the presence of Earth's magnetic field, generate electromagnetic- (Lorentz-) forces in the conductive crust, which then trigger the release of stress-strain-energy and cause earthquakes and fractures in Earth's crust, which then result in increased -volcanism & -hydrotherm. activity

(**Note** : the magnetic-field-fluctuations during a strong geomagnetic storm can induce big currents with ≥ 500V into long conductors., which can be long powerlines (with hundreds of km length), or in nature for example conductive-fluids or -minerals in long linear fractures in Earth's crust, which then could heat-up suddenly)



There is a number of studies which already indicate that there is a **correlation of Geomagnetic storms with strong earthquakes (earthquakes with M >5.6) which can trigger volcanic-activity**.

→ **see weblinks on the next page (page 5)**

The earthquakes are probably caused by the electric currents induced into conductive material in Earth's crust that cause electromagnetic forces & heat.

→ **Please read also Appendix-2**

Tidal effects caused by Earth's moon and the Sun (e.g. daily- and ≈14-day-tidal periodicities which are caused by Earth's rotation and by the moon's orbit-period) can also trigger earthquakes).

But their impact on Earth's-Volcanism & -Climate Anomalies seems to be rather small (minor) !

→ **See Appendix-1**

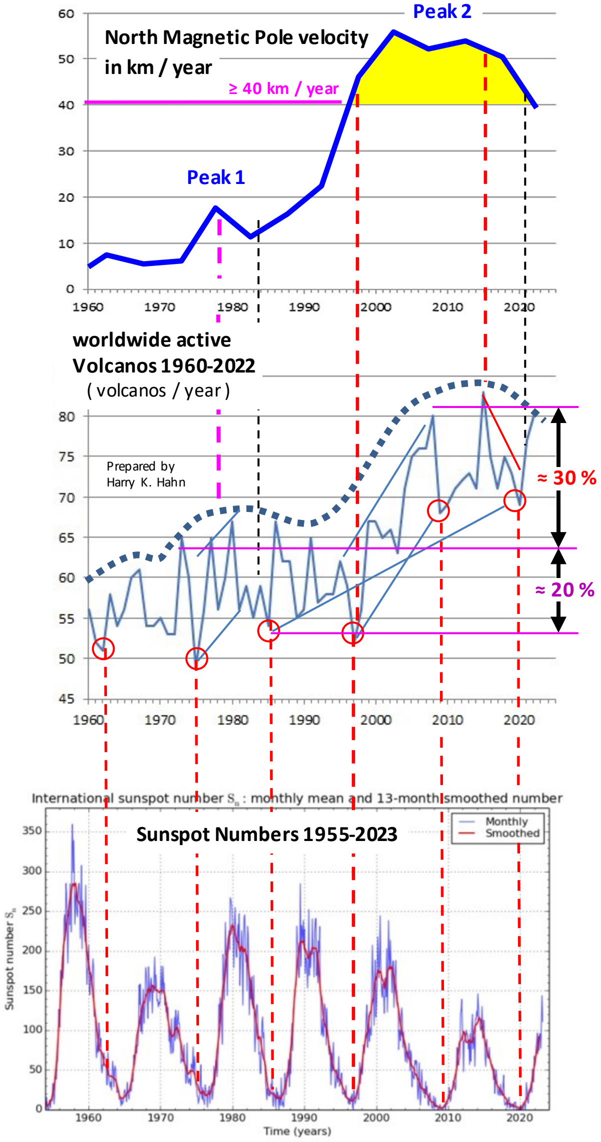
The dominating impact on Earth's volcanism (and on earthquakes & Global Warming) comes from changes of Earth's Geo-magnetism caused by internal processes (e.g. the North-Pole-Shift) and caused by external events (geomagnetic storms).

← **I have created this Chart in order to show the correlation of Geomagnetic Storms with the Earth's Volcanic Activity (→ see Chart on the left)**

(the datas of the global Volcanic Eruptions/year for the time period 1800-2023 are from the Smithsonian Volcanic Program see : Weblink)

3 - Volcanism is correlated to geo-magnetism, HGFA-seismicity, solar-cycles & global warming

A comparison of the 3 charts below indicates that **volcanic activity is influenced by shortterm geo-magnetic effects, caused by the sunspot cycle** (=**space weather**) **and by a longterm geo-magnetic effect, the MPV.** The chart of the **Worldwide Active Volcanos per Year** clearly follows a very **similar trend as** the chart of the **North Magnetic Pole Velocity** (**N-MPV**) if we consider a smoothed chart of the **Active Volcanos/Year** (dotted line) When the **MPV** reached the wide **Peak 2 with ≥ 40 km/year** we can see a **sharp rise & elevation of the volcanic activity**. If we look at the chart of the **worldwide active volcanos per year** we clearly see **sharp rises of activity in the years 1997-99, 2003-07, 2014-15 & 2020-22 interrupted by two drops caused by sunspot cycle minimas** Note that we had **El Ninos events** with inreased **Sea Surface-temperatures** in the years **97/98, 2003-05, 2007 2014-16** and a **new El Nino** episode just started in ≈**2022**. The impact of the high MPV on Volcanism is **≈30%** and that of solar cycles **≈20%**



Further some studies show a clear **correlation of seismic activity in High-geothermal-flux-areas** (**HGFA**) **and the Global Warming** of the last few decades (see : Study & Study-update) → see charts → **HGF-areas** are all mid-ocean-ridge-areas and geothermically active areas (→ **see map in Appendix 3**) It is important to note that there is a **delay of around 2 years between the seismic activity and the reaction of the global climate-system**. (see charts on the right).

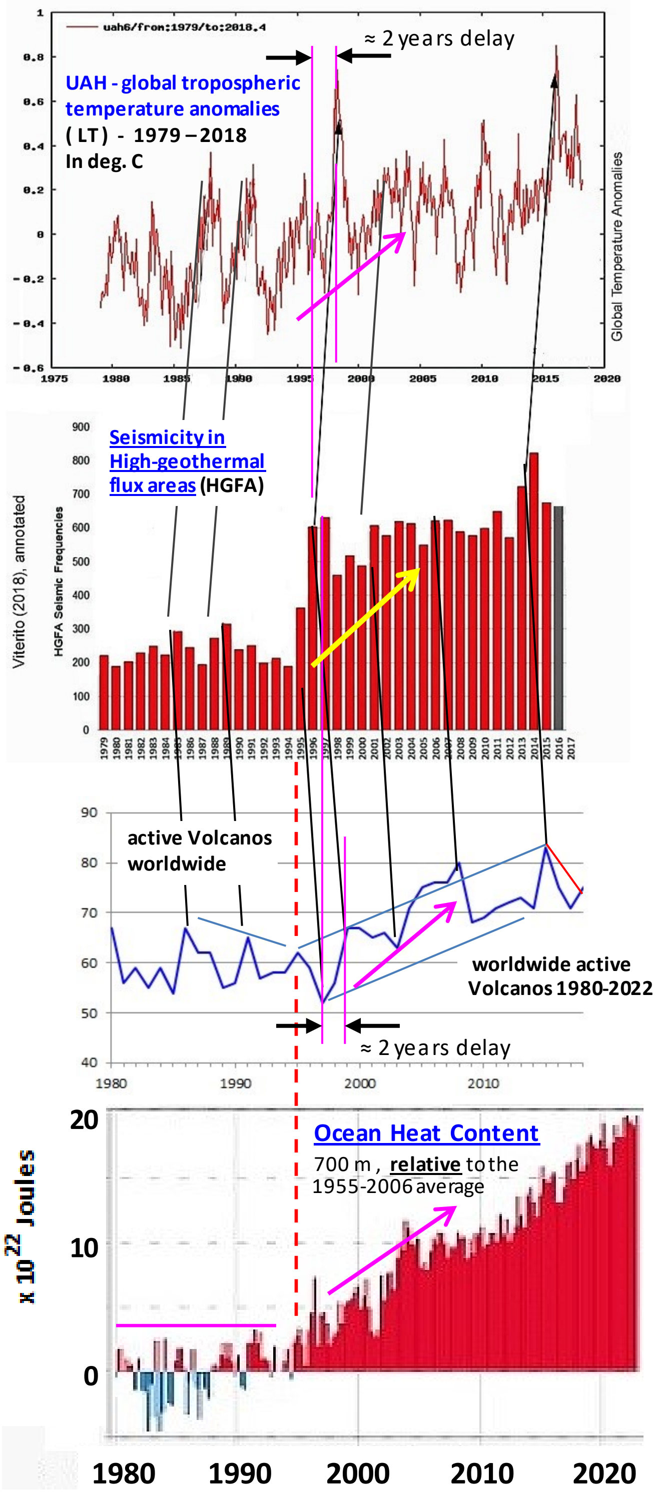
There is also a **delay of ≈ 2 years** noticeable **between the seismic-activity in the HGF-areas and the global volcanism** (in the chart represented by **active volcanos per year**) → see charts on the right. This delay can be explained by the time needed for magma and/or hydrothermal fluids to rise from Earth's mantle and Earth's crust to the surface, after new fractures have opened up in Earth's crust, caused by increased seismicity resulting from the mentioned geo-magnetic effects. (magnetic pole-speed & geomagnetic storms)

Further it's important to note that **the distinct jump in seismic activity** to a higher level **in the HGF-areas**, which we see in the chart **in the years 1995-1997, was followed by a strong increase in the growing-rate of the Ocean Heat Content since around 1996** and followed by a strong peak in global tropospheric-temperature-anomalies (→ see charts on the right).

Here are weblinks to infos & studies that also indicate such correlations:

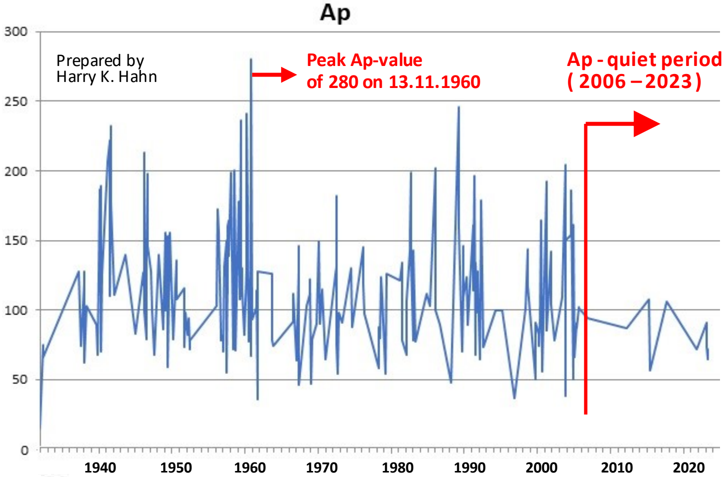
1.) - **Correlation between solar activity and large earthquakes worldwide**
2.) - **A solar-terrestrial effect influences volcanism & global seismic activity**
3.) - **Correlation of geomagnetic anomalies with earthquakes & solar storms**
4.) - **Volcanic eruptions are correlated with Solar Activity**
5.) - **Links of Volcanic Eruptions to Solar Activity and Solar Magnetic Field**

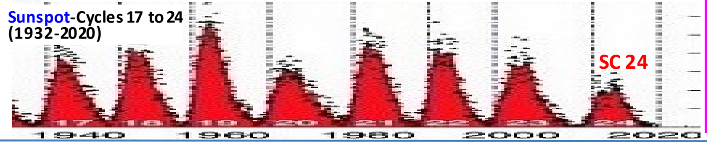
More weblinks to similar studies under References (see last pages)



4 - To the Prediction of future Solar Cycles and Solar Activity

Because there is a correlation of **geomagnetic storms** **with earthquakes, volcanism and** **hydrothermal activity**, **and Global Warming** (→ see page **5**&**7**) we must predict the solar cycles:





Geo-magnetic Storm Chart :

The chart is showing **all days with at least one 3h – ap-value ≥200**

The **Ap-value** **(sum of ap1 to ap8) of these days is shown is the chart**

It is clearly visible in the chart that **Since 2006 no days with higher Ap-values occured anymore !!**

Since 2006 only two days with an Ap-value slightly > 100 occured !!

WARNING !! :

This fact is a clear warning-sign that the Sun has switched to a lower general activity !!

This has a cooling effect on the World's Climate in the future !!

Here theories for longterm predictions of solar cycles: „A mathematical model of the sunspot cycle…"

The model presented here is an attempt to produce a more quantitative prediction of monthly **sunspot-number forecasts** and increase the granularity of the shape of future solar cycles. The model is based primarily on a **Tidal Torque theory** proposed by Ian Wilson (2011) and **two Jovian harmonics** that account for the positioning of three Jovian planets. Wilson's theory proposes that periodic alignments of Venus and the Earth on the same or opposite sides of the Sun produce temporary solar tidal bulges. Jupiter's gravitational force acts on these bulges and either **speeds up or slows down the rotation of the Sun's plasma**, leading to changes in solar activity. The frequency of these alignments on the same side of the Sun is 22.14 yr. Wilson also shows that the strength of the tidal force depends on the heliocentric latitude of Venus and the mean distance of Jupiter from the Sun, and that **when these forces are weakest, solar minimums occur**. This happens approximately every 165.5 yr. The frequency to produce a 165.5 yr beat with 22.14 yr is 19.528 yr. These two frequencies of Venus–Earth–Jupiter (VEJ) interactions are a principle basis for the model. → **Weblink to this** **Study**

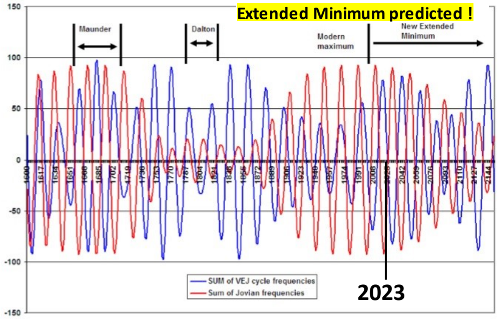


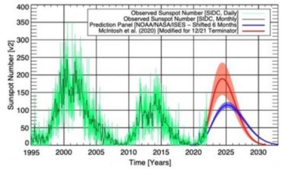
Fig.: The blue line is the interference contribution pattern for the sum of the two Venus-Earth-Jupiter (VEJ)-frequencies (19.528, 22.14), and the red line is the interference contribution for the sum of two Jovian frequencies (19.585, 21.005) to the polarity-adjusted sunspot model **for the years 1600 to 2100**.
The periods of destructive interference during solar minimums and constructive interference during the solar maximum can be seen by inspection of these two interference patterns. At times either the VEJ or Jovian cycles can dominate.

Other studies which are based on the Tidal Torque Theory:

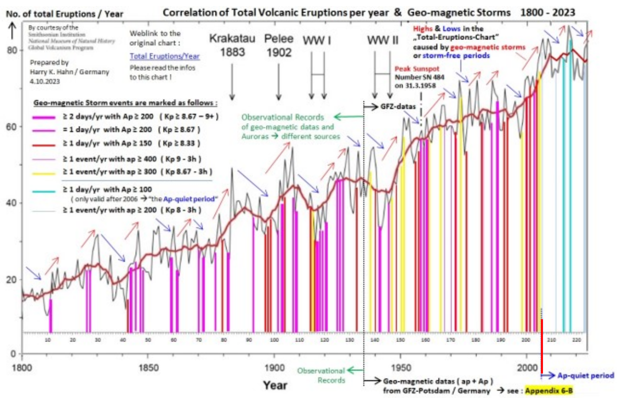
→ Weblinks : Study1 , Study2 , Study3 , Study4

Prediction of the next solar cycle : **→ Weblink to McIntosh's Study**

This theory of **Scott McIntosh** allows to predict one solar cycle precisely in advance. A relationship was found between the temporal spacing of the terminators of the 11yr-sunspot- & 22yr-magnetic sunspot cycles and the magnitude of (future) sunspot cycles.



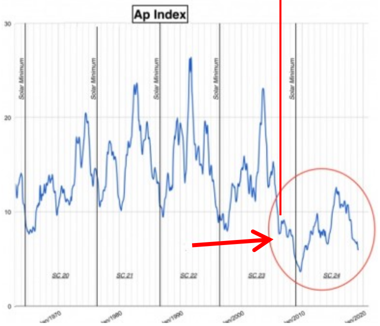
5 - Correlation of Geomagnetic Storms with Global Warming



As described on the previous page there is a clear **correlation visible in the chart, of sharp rises** (highs) **in the "Volcanic Eruptions" –worldwide**, **with the occurence of mainly strong** **Geomagnetic-Storms** (**solar storms**), → indicated by colored lines under the Chart → see on the right

Because these Geomagnetic Storms probably first trigger earthquakes , mainly in the **HGF-areas**, and then with a certain delay of ≈1-2 years the volcanic eruptions follow, **the rises (peaks) in the "Volcanic Eruptions-chart" follow with a slight delay after the** **geo-magnetic storms** **(storm periods).**

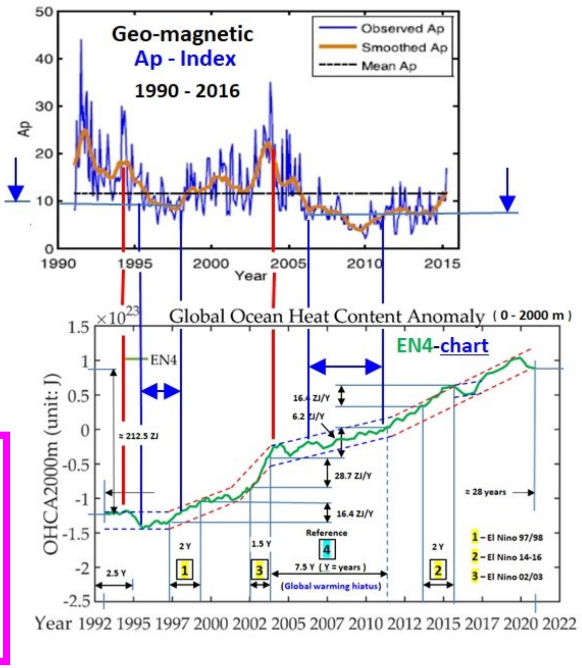
Since ≈2006 it is noticeable that geo-magnetic storms are considerable weaker and they are rarer. These weaker geomagnetic storms are indicated by blue lines und der the chart.



In the chart which shows the geomagnetic **Ap-Index**, which measures the daily average storm-activity, we can see that **there is considerable less activity visible after 2006** (→ see Ap-chart on the right and below !)

Geo-magnetic storm-activity is effecting the World's Climate :

The two charts on the right, the **Ap-Index** and the **Ocean-Heat-Content** (**→ EN4-chart**) of the last ≈30 years indicate that there is a **correlation of geomagnetic storm-activity with the Warming of the Ocean water (0-2000m), described by the Ocean Heat Content.**



Geomagnetic storm-activity causes **earthquakes**, mainly in HGF-areas (e.g. the mid-ocean-ridges), which then causes increased **volcanism** & hydrothermal-vent-activity, mainly in **submarine areas**, and heats-up the ocean water in this way.

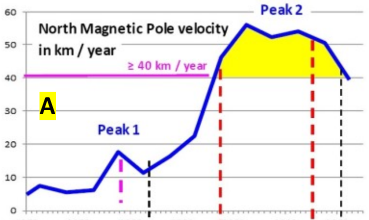
It is clearly visible in the two charts that there is a **correlation of lows with** **AP-values** **below 10 (the top chart) with stagnation-periods (or lows) in the** **Ocean-Heat-Content chart**. **And correlation of at least one major peak in the Ap-chart with a clear peak in the OHC-chart**

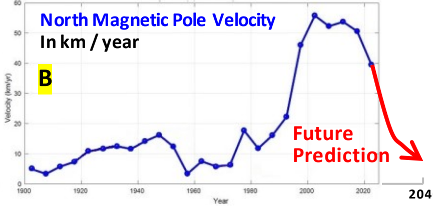
6 - Prediction of future Geomagnetic-changes, Solar-cycles & Climate, based on historical datas → We must predict the future solar-activity !

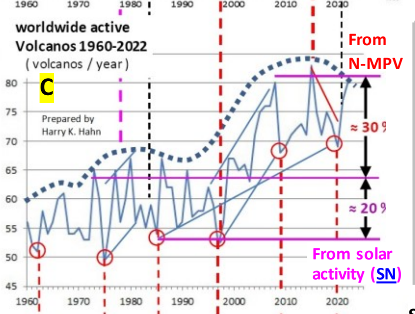
As shown on **page 5** there is a clear correlation between geo-magnetism, solar-cycles, HGFA-**seismicity**, **Volcanism** & **Global Warming** The geo-magnetic-**changes** near the **Earth's** core-mantle-boundary, which have caused the **fast shift** of the North Magnetic Pole, have an impact of ≈ **+30%** and Geo-magnetic Storms caused by solar-cycles have an impact of ≈ **+/- 20%** on **Global Volcanism**, as **Chart C** (& **A**+**D**) indicate. **Changes in Geo-magnetism & Solar-cycles are responsible for ≥40% of Global Warming ! See also my Study-1** !

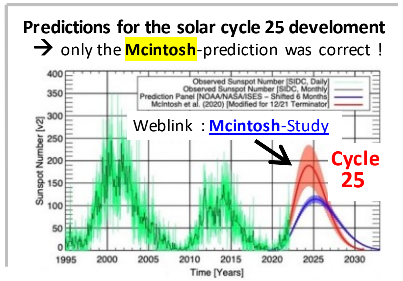
The same flow-patterns (mass streams) inside of **Earth's mantle**, which cause the **fast North Magnetic Pole Shift** (**N-MPV**) (see chart **A**+**B**) are also responsible for increased **Worldwide Volcanic Activity** (chart **C**) and increased **seismic- & geothermal-activity in HGF-areas** on Earth, which caused the **increased Ocean-Heat-Content (OHC)** & the **Global Warming** (→ **see Chart Y**) especially in the period **1997 to 2023** (charts **A+C+Y**)

→ This page was prepared by Harry K. Hahn



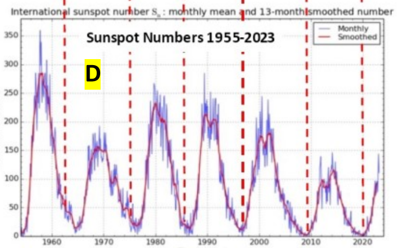


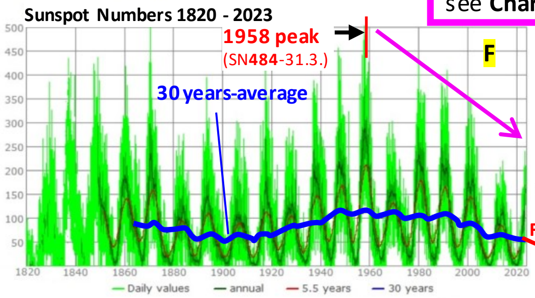



Predictions for the solar cycle 25 develoment

→ only the **Mcintosh**-prediction was correct !

Weblink : Mcintosh-Study





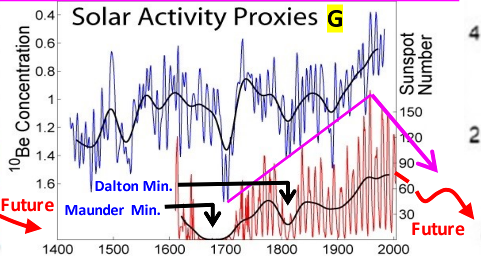
Prediction of future Solar-Activity Volcanic Activity & Global Warming:

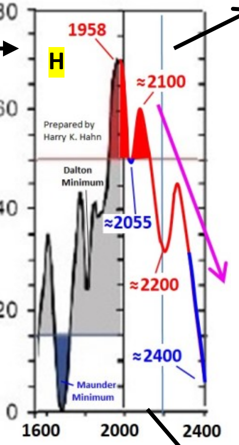
In the **Chart B** we can see that the **velocity of the North Magnetic Pole** dropped **below 40 km/year** in **≈2022** and it will in all probabilty drop to **≤10 km/year** in **≈2040** and then it will probably stagnate for many decades

This means **the contribution of the N-MPV of ≈30%** to Global Volcanism (& to geo-thermal activity + OHC) **will disappear** in ≈10-20 years (**Chart A-C**)

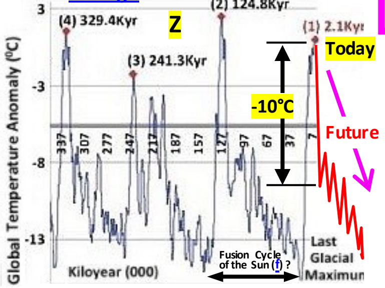
11000 years ago the solar activity (average sunspot number (**SN**) was as high as today (see **Chart E**) → see **Ref. Period 1**. But the Sun can only hold this high level of activity for ≈120-150 years ! Therefore since **1958** (max. **SN-peak**) we are on the way to a considerable lower level of solar activity with an **average ≤ 40 SN** (see **E** & **H**). This corresponds to a cooler world climate, as the **Dalton Minimum** 1790-1830

The **Chart H** shows my future prediction for the solar activity & **SN**. This is also indicated by **F** & **G** We go to a cooler (SN)-climate as the correlation between geo-magnetic **Ap-Index** & **OHC** shows ! see **Charts X & Y** (& chart **Z**) see also **my Study-1**





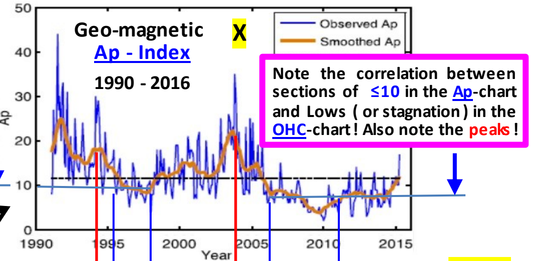
Ice-Age chart :



Temperature anomaly chart of the last 330 000 years (relative to 2000 CE)
The red line shows the future projection
Temperatures will drop at least -10°C in the next ≈ 2400 years !! (→ -0.4°C / 100y)

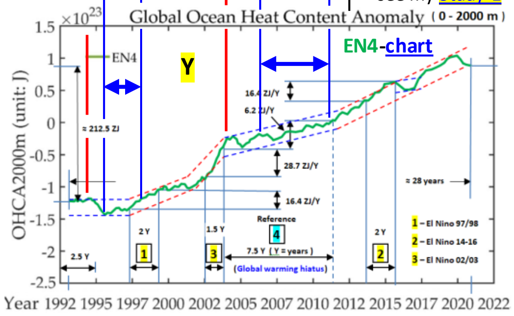
The Ocean Heat Content in the depth-ranges 0-5500 m and 2000-5500 m did not increase in the time-period 1950-1990 !! (see chart **K**)
Note : It actually dropped in that time-period especially in the depth-range 2000 - 5500 m !!

This can mean only one thing: **The ocean water was heated from below, from the ocean-floor, in particular → from the HGF-areas ! in the time ≈ 1995-2023.** (→ **see Chart K**) Otherwise the quick warming of water in **depths >2000 m** can't be explained ! **If heated from the surface** (caused e.g. by increased air-temperature), **then the ocean water would have needed decades if not centuries to heat up in depths 2000-5500 m !!**

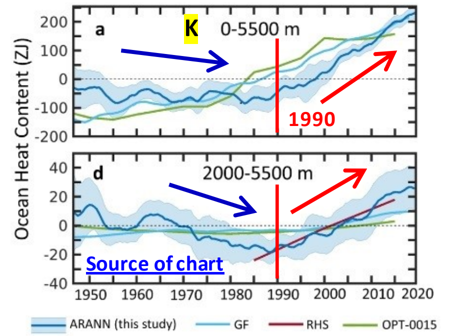


Note the correlation between sections of ≤10 in the Ap-chart and Lows (or stagnation) in the OHC-chart ! Also note the peaks !

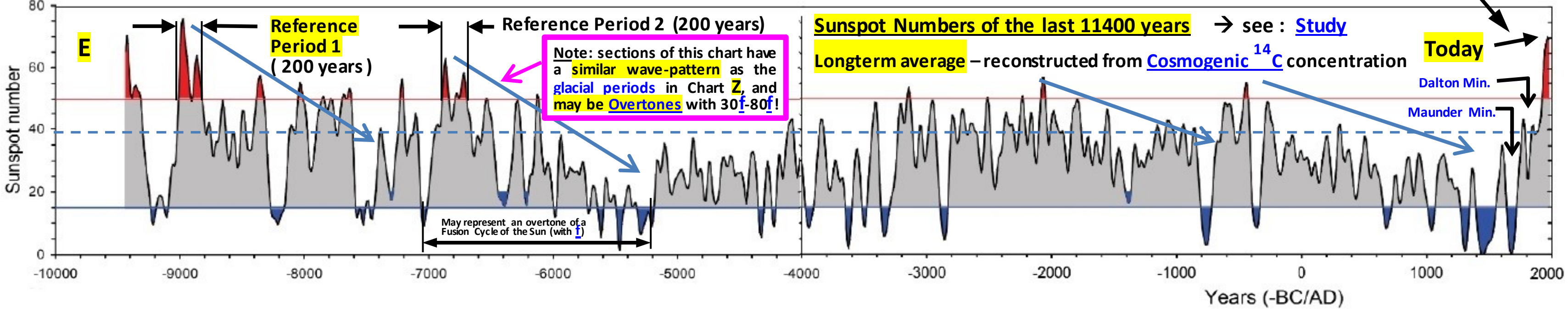
see my Study-1



Ocean Heat Content in 0-5500 & 2000-5500m



Source of chart



Note: sections of this chart have a similar wave-pattern as the glacial periods in Chart **Z**, and may be Overtones with 30f-80f !

Sunspot Numbers of the last 11400 years → see : Study

Longterm average – reconstructed from Cosmogenic ^{14}C concentration

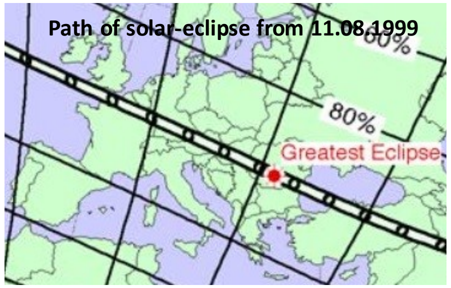
Appendix 1 : Earthquakes caused by tidal forces (gravitational forces)

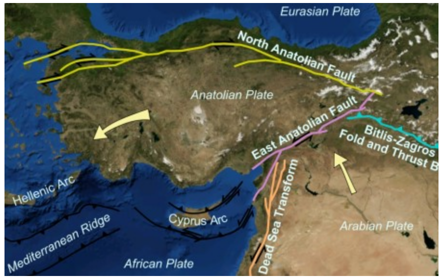
Different statistical tools indicate that earthquakes are organized in time according to certain renewal intervals. These intervals (time periods) between earthquakes with the highest probability of their appearance are represented in the Fourier Power Spectra and in the **Schuster Spectra** by the highest peaks in the Spectra (→ see the diagrams further below)

There is a high correlation between tidal events (tidal forces) caused by the moon and sun and tectonic earthquakes, and earthquakes in the mid-ocean-ridge-areas (=HGF-areas). Tidal stress caused by Sun & Moon, is superimposed on tectonic-stress and plays a triggering role for such earthquakes. Strong earthquakes (≥M7), such as the 2011 Tohoku-Oki-earthquake often occur near the maximal tidal stress amplitude. The **M 7.6** Gölcük-earthquake from 17.8.99 in Turkey which occured just 6 days after a solar-eclipse was also caused by maximal tidal stress ! Beside daily- and ≈14-day-tidal periodicities which are caused by Earth's rotation and by the moon's orbit-period, there is also one longterm tidal periodicity caused by the moon, which seems to be presented by the **18-20 year peak** in the Schuster- (Fourier-) Spectra This periodicity probably is caused by the **18 year** Saros-period. Because after a solar-eclipse Earth, Sun & Moon reach the same geometry, after one Saros-period and a similar solar-eclipse (tidal event) follows. →Studies about tidal triggers: **Study1**, **Study2**, **Study3**

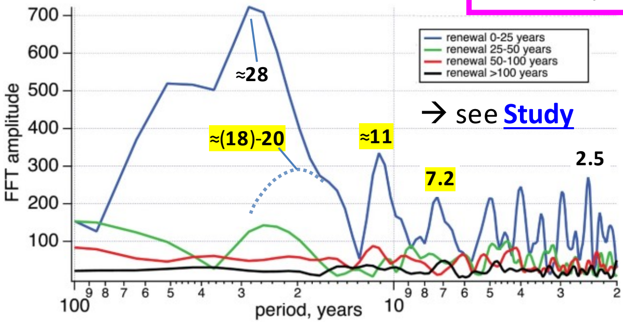
Note : The strong **11-year peak** in the spectra is caused by the **11-year solar-cycle**. And the big **7.2 year peak** & other peaks with shorter periods (e.g. 2.5) probably are caused by **magnetic waves** emitted from Earth's core (Study **Part-2**). Changes in Earth's magnetic field caused by these factors trigger **earthquakes+ volcanism**

I want to contribute here an example of a powerful earthquake which surely was triggered by a maximal tidal stress amplitude. The **M 7.6 Gölcük-earthquake** from **17.8.1999** in Turkey which occured **just 6 days after the solar eclipse from 11.8.1999**. **Note that the core-shadow** (→gravity force vectors of moon and sun in line) **moved ≈ 20 minutes precisely along the North Anatolian fault, probably the crucial fact here !**





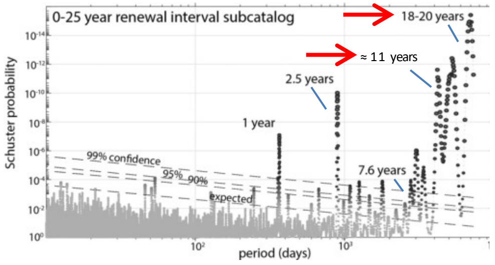
Satellite map of Turkey with tectonic fault lines



→ see **Study**

Fourier spectra results - complementary to the Schuster spectra

Time series of annual earthquake productivity for different renewal interval subcatalogs. Indicating power at frequencies which are also identified in the Schuster-spectra. For example the strong peaks at 2.5, 7.2 , 11 & 20 years and other resolved peaks at 3, 4, 5 and 28 years (for the 1-25 year catalog)

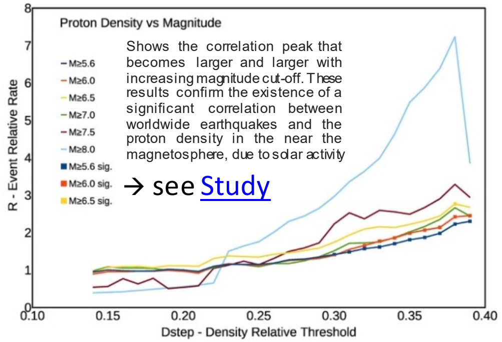


Schuster spectra for 1-25 year subcatalog of earthquakes

The logarythmic diagram of the Schuster probability for the subcatalog of earthquake events with the renewal interval of 1-25 years shows a number of strong peaks. For example at 1, 2.5, 7.6 and 18-20 years periods (with >99% confidence)

Appendix 2: Earthquakes (& Volcanism) caused by Geomagnetic storms

Large earthquakes occurring worldwide have long been recognized to be non-Poisson distributed, so involving some **large scale correlation mechanism**, which could be internal &/or external to the Earth. **Clear correlation was found between increased proton density, during solar-cycle maximas & during geomagn. Storms (solar storms), and the occurance of earthquakes with magnitude > M 5.6.**



Shows the correlation peak that becomes larger and larger with increasing magnitude cut-off. These results confirm the existence of a significant correlation between worldwide earthquakes and the proton density in the near the magnetosphere, due to solar activity

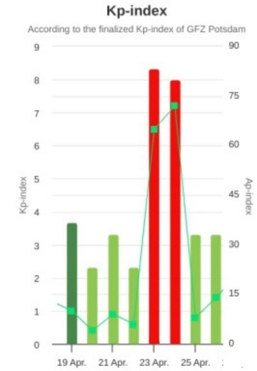
→ see Study

Plots of the Event Relative Rate R as a function of the normalized proton density, and for the condition 1Dy bT (earthquakes occurring within 24 h from the value of density decreasing below the threshold value). Colours indicate different lower cut-off magnitudes in the catalogue

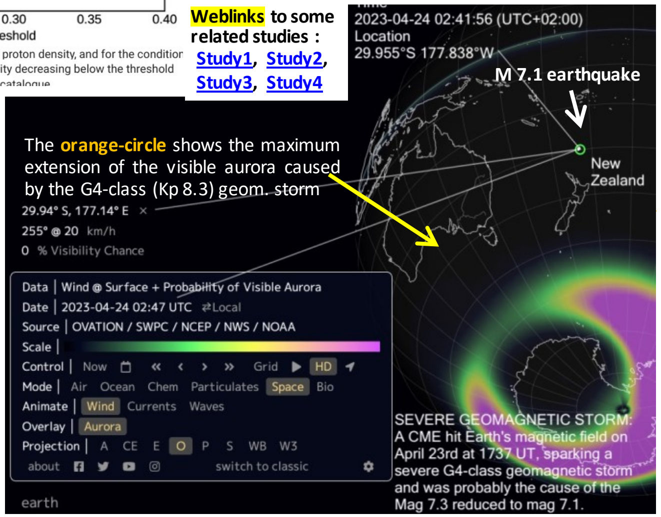
The currents generated by solar winds in the ionosphere cause magnetic field fluctuation on the Earth's surface, inducing electrical currents, which penetrate into the Earth and, in the presence of Earth's magnetic field, generate electromagnetic (Lorentz) force, which can trigger the release of stress strain energy and can cause earthquakes and fractures in Earth's crust.

The map below shows the **aurora australis** caused by a **G4-geomagnetic storm on 23.4.2023** & the location of a **M 7.1 earthquake** in the **Kermadec-Arc** that occured **≈7 hours after the start of the storm. The probability for >M7 earthquakes** in this 8h-period **was only 1: 180**

Weblinks to some related studies :
Study1, **Study2**,
Study3, **Study4**



Kp-index of the geomagnetic storm on 23.4. to 24.4.2023


2023-04-24 02:41:56 (UTC+02:00)
Location
29.955°S 177.838°W

M 7.1 earthquake

The orange-circle shows the maximum extension of the visible aurora caused by the G4-class (Kp 8.3) geom. storm

29.94° S, 177.14° E
255° @ 20 km/h
0 % Visibility Chance

Data | Wind @ Surface + Probability of Visible Aurora
Date | 2023-04-24 02:47 UTC
Source | OVATION / SWPC / NCEP / NWS / NOAA
Scale |
Control | Now « ‹ › » Grid ▶ HD
Mode | Air Ocean Chem Particulates Space Bio
Animate | Wind Currents Waves
Overlay | Aurora
Projection | A CE E O P S WB W3

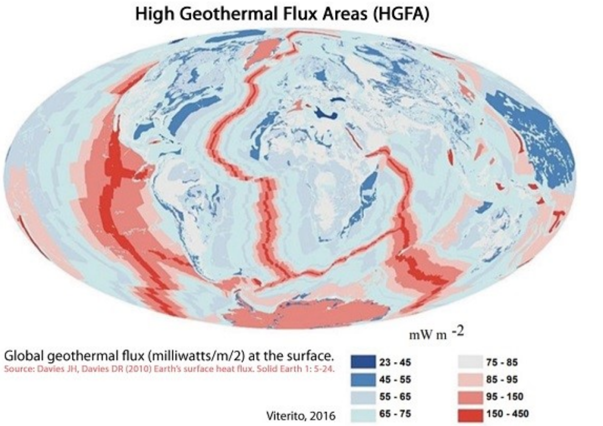
SEVERE GEOMAGNETIC STORM: A CME hit Earth's magnetic field on April 23rd at 1737 UT, sparking a severe G4-class geomagnetic storm and was probably the cause of the Mag 7.3 reduced to mag 7.1.

Appendix 3: High Geothermal Flux Areas (HGFA) – World Map

Note :

HGF-areas are all mid-ocean-ridge-areas and the geo-thermically active areas

(→ see map)


High Geothermal Flux Areas (HGFA)

Global geothermal flux (milliwatts/m/2) at the surface.
Source: Davies JH, Davies DR (2010) Earth's surface heat flux. Solid Earth 1: 5-24.

Viterito, 2016

mW m $^{-2}$	
23 - 45	75 - 85
45 - 55	85 - 95
55 - 65	95 - 150
65 - 75	150 - 450

Appendix 6-A : Table 1 : worldwide Active Volcanos / & -Eruptions per year - Datas from the Smithsonian Volcanism Program (left side of table)

→ active volcanos per year were separated into selected regions (right side of table) → to see all volcanos of a certain year clic on the year (left column)

Year	Eruptions Started (New)	Eruptions Ended	Eruptions Total	Volcanos Active (globally)	Countries	VEI <= 2	VEI 3	VEI 4	VEI 5	VEI 6
1960	35	18	58	56	20	26	9	0	0	0
1961	32	25	56	52	21	27	5	0	0	0
1962	29	21	52	51	17	24	5	0	0	0
1963	40	27	64	58	20	31	8	0	1	0
1964	29	29	58	54	21	27	1	1	0	0
1965	34	27	60	56	24	27	6	1	0	0
1966	35	32	63	60	23	24	9	2	0	0
1967	43	31	66	61	24	37	6	0	0	0
1968	32	29	58	54	22	24	7	1	0	0
1969	32	29	57	54	22	30	2	0	0	0
1970	34	25	57	55	23	28	6	0	0	0
1971	32	28	56	53	20	27	5	0	0	0
1972	30	22	55	53	22	25	5	0	0	0
1973	41	29	69	65	21	35	5	1	0	0
1974	27	32	64	60	19	22	4	1	0	0
1975	23	16	52	49	22	21	1	1	0	0
1976	29	23	61	56	23	27	1	1	0	0
1977	39	35	73	65	26	35	4	0	0	0
1978	25	22	58	56	22	23	2	0	0	0
1979	32	24	65	60	22	28	4	0	0	0
1980	41	36	74	67	25	31	9	0	1	0
1981	29	24	60	56	24	22	5	2	0	0
1982	32	35	64	59	22	27	3	1	1	0
1983	32	24	58	55	20	25	6	1	0	0
1984	33	29	64	59	23	28	5	0	0	0
1985	27	25	60	54	25	22	5	0	0	0
1986	41	38	75	67	28	32	6	3	0	0
1987	32	23	64	62	23	29	3	0	0	0
1988	27	30	64	62	24	23	4	0	0	0
1989	25	26	57	55	24	23	2	0	0	0
1990	30	27	60	56	22	23	6	1	0	0
1991	37	29	67	65	27	31	4	0	1	1
1992	27	24	61	57	24	24	2	1	0	0
1993	27	28	60	58	24	25	1	1	0	0
1994	33	27	62	58	22	28	4	1	0	0
1995	33	36	65	62	29	29	4	0	0	0
1996	35	26	61	59	23	29	6	0	0	0
1997	26	25	56	52	23	22	4	0	0	0
1998	32	23	59	56	24	27	5	0	0	0
1999	39	31	70	67	26	34	4	1	0	0
2000	39	38	75	67	29	34	4	1	0	0
2001	33	36	70	65	26	27	6	0	0	0
2002	41	34	74	66	25	36	3	2	0	0
2003	29	32	65	63	25	24	5	0	0	0
2004	49	42	81	71	27	41	7	1	0	0
2005	46	38	83	75	28	39	7	0	0	0
2006	44	41	86	76	29	39	4	1	0	0
2007	36	38	81	76	29	30	6	0	0	0
2008	45	39	86	80	28	36	6	3	0	0
2009	31	31	75	68	25	28	2	1	0	0
2010	33	37	77	69	24	21	10	2	0	0
2011	36	36	76	71	28	31	2	2	1	0
2012	41	38	81	72	27	36	5	0	0	0
2013	37	42	80	73	29	29	7	1	0	0
2014	41	33	79	71	31	30	8	3	0	0
2015	44	40	90	83	31	37	5	2	0	0
2016	36	45	86	75	28	30	6	0	0	0
2017	33	31	74	71	29	26	6	1	0	0
2018	37	32	80	75	28	31	6	0	0	0
2019	27	29	75	73	28	22	3	2	0	0
2020	28	25	74	69	29	22	4	2	0	0
2021	34	31	83	77	30	31	1	1	1	0
2022	33	35	85	80	28	32	1	0	0	0
2023 (7.9.23)	16	17	66	65	28					

Active Volcanos per year - separated into selected regions

Year	Indonesia	Ecuador, Colombia Guatemala Costa Rica, El Salador Nicaragua	Papua New Guinea New Zealand Tonga, Australia Samoa,Vanuatu	Japan	Russia (Kamchatka)	Aleuten + Alaska (USA)	Phillipines	Indonesia + Phillipines	Iceland (5 major volcanos) BAR, EYJ, GRV, HEK, KAT	Mariana Islands (USA)	North-America (USA with-out Alaska)	Hawaii	Mexico		all others	Ethiopia, Tanzania, Eritrea, Dschibuti	
1960	6	5	10	9	8	3	0	6	0	0	0	1	1		11	2	Ethiopia +Tanzania
1961	9	6	7	5	9	3	0	9	0	0	0	1	1		10	1	Tanzania
1962	6	6	12	9	5	4	0	6	0	0	0	1	1		6	1	
1963	11	9	12	9	6	6	0	11	0	0	0	1	1		2	1	
1964	12	5	9	7	8	4	0	12	0	0	0	0	1		7	1	
1965	12	8	12	8	6	0	1	13	0	0	0	1	1		6	1	Tanzania
1966	13	11	11	5	4	4	1	14	0	1	0	0	1		8	1	Tanzania
1967	13	8	10	5	8	4	1	14	0	1	0	1	1		7	2	Ethiopia +Tanzania
1968	11	9	11	8	3	3	2	13	0	1	0	1	1		3	1	Ethiopia
1969	10	10	10	7	4	1	3	13	0	1	0	1	1		5	1	Ethiopia
1970	12	9	10	8	6	0	2	14	1	0	0	1	1		5	1	
1971	10	9	11	6	4	2	0	10	0	0	0	1	0		9	1	
1972	8	10	11	4	5	0	0	8	0	0	0	1	0		13	1	
1973	15	10	13	9	5	4	0	15	0	0	0	1	0		5	1	
1974	10	15	14	10	3	6	0	10	0	1	0	1	0		-1	1	
1975	8	8	10	7	2	3	0	8	0	0	0	2	1		7	1	
1976	8	13	13	6	4	4	1	9	0	0	0	0	1		5	1	
1977	8	**17**	14	5	3	5	1	9	0	0	0	1	1		9	1	
1978	8	12	11	8	3	3	4	12	0	0	0	0	1		4	2	Ethiopia + Dschibuti
1979	10	10	16	7	4	1	1	11	0	0	0	1	1		8	1	Ethiopia
1980	9	10	13	8	8	5	2	11	1	0	1	1	1		8	1	
1981	7	11	9	6	7	3	1	8	0	1	1	0	1		8	1	
1982	10	10	10	8	6	2	0	10	0	1	1	1	2		7	1	Ethiopia
1983	12	8	7	7	2	5	1	13	1	1	1	1	0		8	2	Ethiopia +Tanzania
1984	10	9	13	6	4	3	1	11	0	1	1	2	0		7	2	Ethiopia +Tanzania
1985	8	12	12	4	5	0	2	10	0	2	1	1	1		4	2	
1986	10	10	12	4	11	6	1	11	0	0	1	1	1		8	2	
1987	11	10	7	5	4	11	1	12	0	1	0	1	1		8	2	
1988	14	9	9	7	4	3	2	16	0	1	0	1	0		10	2	
1989	8	8	10	8	5	3	1	9	0	1	1	1	0		7	2	
1990	9	8	10	6	4	5	0	9	0	0	1	1	0		10	2	
1991	12	10	10	6	5	2	2	14	1	0	1	1	1		13	2	
1992	10	9	8	6	4	6	3	13	0	1	0	1	0		7	2	
1993	13	9	8	5	3	4	3	16	0	1	0	1	1		8	2	
1994	12	7	8	5	4	4	1	13	0	1	0	1	3		10	2	
1995	9	8	12	6	3	5	1	10	0	1	0	1	1		11	2	
1996	9	7	9	8	5	3	1	10	1	1	1	2	1		10	2	
1997	6	8	9	6	6	5	0	6	0	0	0	1	2		7	2	
1998	10	8	9	5	4	3	0	10	1	0	0	1	2		12	2	
1999	16	12	13	6	5	1	1	17	1	0	0	1	2		8	2	
2000	13	12	12	8	8	0	2	15	0	0	0	1	2		7	2	
2001	12	11	14	6	5	1	1	13	0	1	0	1	2		9	2	
2002	12	13	13	5	7	2	2	14	0	0	0	1	2		7	2	
2003	10	8	13	5	5	1	2	12	0	2	0	1	2		10	2	
2004	11	12	15	8	6	2	1	12	1	2	1	1	2		8	2	Ethiopia +Tanzania
2005	9	16	14	5	7	5	2	11	0	2	1	1	2		8	3	2xEthiopia +Tanzania
2006	8	15	19	5	3	5	5	13	0	3	1	1	2		7	2	Ethiopia +Tanzania
2007	13	14	17	3	5	3	1	14	0	2	1	1	2		11	3	2xEthiopia +Tanzania
2008	11	19	15	8	6	4	1	12	0	2	1	1	2		7	3	2xEthiopia +Tanzania
2009	12	14	11	4	8	4	1	13	0	1	0	1	2		7	3	2xEthiopia +Tanzania
2010	11	15	10	5	9	1	2	13	1	3	0	1	2		8	2	Ethiopia +Tanzania
2011	14	16	10	4	5	1	1	15	2	1	0	1	2		12	4	2xE + Tanzania + Eritrea
2012	16	16	15	5	8	2	0	16	0	1	0	1	1		5	2	Ethiopia +Tanzania
2013	18	13	9	6	10	3	1	19	0	1	0	1	2		7	2	
2014	15	14	12	7	6	4	1	16	1	2	0	1	2		5	2	
2015	16	19	8	9	10	2	2	18	1	1	0	1	2		11	2	
2016	11	18	10	5	13	3	3	14	0	0	0	1	2		7	2	
2017	12	14	11	4	8	2	2	14	0	0	0	1	2		13	2	
2018	14	17	12	6	8	4	1	15	0	0	0	1	1		9	2	
2019	12	11	12	7	7	5	1	13	0	0	0	0	2		14	2	
2020	14	13	10	9	6	3	1	15	1	0	0	1	1		9	2	
2021	12	12	14	7	8	4	3	15	0	1	0	1	1		12	2	
2022	11	16	15	6	7	3	4	15	0	1	0	2	1		12	2	
2023 (7.9.23)	10	11	13	5	5	3	1			1						2	Ethiopia +Tanzania

Appendix 6-B : Table 2 : Geo-magnetic-storm days → All days with an 3h – ap-value > 200 are listed from 1932 to mid-2023

➔ datas from the GFZ-Potsdam → weblink to GFZ-homepage : https://kp.gfz-potsdam.de/

YYYY	MM	DD	days	days_m	Bsr	dB	Kp1	Kp2	Kp3	Kp4	Kp5	Kp6	Kp7	Kp8	ap1	ap2	ap3	ap4	ap5	ap6	ap7	ap8	Ap	SN	F10.7obs	F10.7adj	D
1932	5	29	149	149.5	1357	24	2.333	3.000	2.667	4.333	6.667	7.000	6.667	7.667	9	15	12	32	111	132	111	179	**75**	17	-1.0	-1.0	2
1932	5	30	150	150.5	1357	25	7.000	8.000	6.333	3.000	2.667	3.667	4.333	3.000	132	207	94	15	12	22	32	15	**66**	17	-1.0	-1.0	2
1937	4	28	1944	1944.5	1424	10	7.000	8.000	8.000	7.333	6.667	6.667	5.000	5.333	132	207	207	154	111	111	48	56	**128**	248	-1.0	-1.0	2
1937	8	22	2060	2060.5	1428	18	1.333	6.000	8.000	7.667	5.667	3.000	4.333	2.333	5	80	207	179	67	15	32	9	**74**	172	-1.0	-1.0	2
1938	1	17	2208	2208.5	1434	4	6.667	6.333	6.667	6.333	8.333	7.667	4.667	6.333	111	94	111	94	236	179	39	94	**120**	183	-1.0	-1.0	2
1938	1	22	2213	2213.5	1434	9	5.667	7.333	8.333	8.333	6.667	7.000	5.333	4.333	67	154	236	236	111	132	56	32	**128**	203	-1.0	-1.0	2
1938	1	25	2216	2216.5	1434	12	4.000	2.667	1.667	4.667	6.000	7.333	8.667	8.333	27	12	6	39	80	154	300	236	**107**	157	-1.0	-1.0	2
1938	1	26	2217	2217.5	1434	13	8.333	6.333	4.333	4.667	4.000	4.333	4.000	2.000	236	94	32	39	27	32	27	7	**62**	127	-1.0	-1.0	2
1938	5	11	2322	2322.5	1438	10	2.667	2.667	2.000	2.333	2.000	7.667	8.667	8.667	12	12	7	9	7	179	300	300	**103**	248	-1.0	-1.0	2
1939	10	13	2842	2842.5	1457	17	5.000	5.667	6.333	4.000	3.667	5.667	7.667	8.000	48	67	94	27	22	67	179	207	**89**	142	-1.0	-1.0	2
1939	10	15	2844	2844.5	1457	19	6.667	8.000	6.667	3.333	3.333	4.667	4.000	3.000	111	207	111	18	18	39	27	15	**68**	122	-1.0	-1.0	2
1940	3	24	3005	3005.5	1463	18	6.333	6.000	5.000	4.333	8.000	9.000	9.000	8.333	94	80	48	32	207	400	400	236	**187**	192	-1.0	-1.0	2
1940	3	25	3006	3006.5	1463	19	8.667	8.333	8.333	8.000	7.000	4.667	6.667	8.000	300	236	236	207	132	39	111	207	**184**	168	-1.0	-1.0	2
1940	3	29	3010	3010.5	1463	23	2.667	1.667	2.333	5.000	5.000	8.333	8.000	8.333	12	6	9	48	48	236	207	236	**100**	163	-1.0	-1.0	2
1940	3	30	3011	3011.5	1463	24	8.667	8.333	8.333	8.000	7.333	7.667	7.000	5.667	300	236	236	207	154	179	132	67	**189**	143	-1.0	-1.0	2
1940	3	31	3012	3012.5	1463	25	7.000	5.333	4.667	8.333	8.000	7.667	6.000	6.333	132	56	39	236	207	179	80	94	**128**	142	-1.0	-1.0	2
1940	4	3	3015	3015.5	1464	1	8.000	8.000	7.000	4.667	4.667	5.000	6.333	3.667	207	207	132	39	39	48	94	22	**98**	108	-1.0	-1.0	2
1940	4	25	3037	3037.5	1464	23	4.667	8.000	4.000	1.667	2.333	5.000	6.667	6.667	39	207	27	6	9	48	111	111	**70**	93	-1.0	-1.0	2
1940	6	25	3098	3098.5	1467	3	4.667	7.000	5.333	7.333	8.333	7.667	7.333	5.333	39	132	56	154	236	179	154	56	**126**	180	-1.0	-1.0	2
1941	3	1	3347	3347.5	1476	9	3.000	6.333	8.000	8.000	8.667	9.000	8.667	7.000	15	94	207	207	300	400	300	132	**207**	77	-1.0	-1.0	2
1941	7	5	3473	3473.5	1480	27	6.333	6.333	8.667	8.667	9.000	8.667	6.667	7.667	94	94	300	300	400	300	111	179	**222**	78	-1.0	-1.0	2
1941	8	4	3503	3503.5	1482	3	5.000	7.000	6.000	5.667	8.333	6.667	6.333	6.667	48	132	80	67	236	111	94	111	**110**	155	-1.0	-1.0	2
1941	9	18	3548	3548.5	1483	21	2.000	6.667	8.333	8.667	8.667	8.667	8.667	8.667	7	111	236	300	300	300	300	300	**232**	233	-1.0	-1.0	2
1941	9	19	3549	3549.5	1483	22	8.667	9.000	8.667	7.333	4.000	5.000	7.333	4.000	300	400	300	154	27	48	154	27	**176**	220	-1.0	-1.0	2
1942	3	1	3712	3712.5	1489	23	3.333	2.667	8.000	8.000	7.333	5.667	6.667	6.667	18	12	207	207	154	67	111	111	**111**	212	-1.0	-1.0	2
1943	8	31	4260	4260.5	1510	4	7.000	8.333	7.333	7.333	7.667	7.000	6.333	4.667	132	236	154	154	179	132	94	39	**140**	0	-1.0	-1.0	2
1944	12	16	4733	4733.5	1527	18	4.000	3.667	4.333	6.000	8.000	8.333	5.000	3.000	27	22	32	80	207	236	48	15	**83**	53	-1.0	-1.0	2
1946	2	7	5151	5151.5	1543	4	3.667	2.000	4.000	8.333	7.667	8.000	7.000	8.000	22	7	27	236	179	207	132	207	**127**	182	-1.0	-1.0	2
1946	2	8	5152	5152.5	1543	5	8.667	7.667	7.333	7.000	5.667	5.667	4.000	3.000	300	179	154	132	67	67	27	15	**118**	170	-1.0	-1.0	2
1946	3	24	5196	5196.5	1544	22	8.000	7.667	5.000	5.667	7.333	8.000	3.333	5.333	207	179	48	67	154	207	18	56	**117**	123	-1.0	-1.0	2
1946	3	25	5197	5197.5	1544	23	7.667	7.333	7.333	7.667	8.333	8.667	7.667	7.667	179	154	154	179	236	300	179	179	**195**	92	-1.0	-1.0	2
1946	3	28	5200	5200.5	1544	26	5.000	6.000	8.333	8.667	8.667	8.667	8.333	8.000	48	80	236	300	300	300	236	207	**213**	100	-1.0	-1.0	2
1946	4	23	5226	5226.5	1545	25	3.667	4.000	5.333	6.000	6.333	7.667	7.667	8.667	22	27	56	80	94	179	179	300	**117**	102	-1.0	-1.0	2
1946	4	24	5227	5227.5	1545	26	8.333	7.333	6.667	6.333	4.333	6.667	4.667	3.333	236	154	111	94	32	111	39	18	**99**	97	-1.0	-1.0	2
1946	7	26	5320	5320.5	1549	11	3.667	4.000	3.000	3.667	3.333	3.333	8.667	8.000	22	27	15	22	18	18	300	207	**79**	200	-1.0	-1.0	2
1946	7	27	5321	5321.5	1549	12	8.667	8.667	9.000	6.667	5.333	3.667	3.667	2.333	300	300	400	111	56	22	22	9	**152**	285	-1.0	-1.0	2
1946	9	22	5378	5378.5	1551	15	3.667	8.333	7.667	8.667	9.000	8.333	7.000	6.000	22	236	179	300	400	236	132	80	**198**	168	-1.0	-1.0	2
1946	9	23	5379	5379.5	1551	16	7.333	7.667	8.000	6.333	7.000	8.000	6.000	6.667	154	179	207	94	132	207	80	111	**146**	222	-1.0	-1.0	2
1947	3	3	5540	5540.5	1557	15	7.000	5.000	6.667	7.000	6.333	5.667	8.333	8.000	132	48	111	132	94	67	236	207	**128**	156	0.0	0.0	2
1947	4	17	5585	5585.5	1559	6	3.667	3.667	1.667	1.667	6.333	6.667	8.667	8.333	22	22	6	6	94	111	300	236	**100**	110	156.8	158.1	2
1947	7	17	5676	5676.5	1562	16	1.000	0.667	0.667	2.000	1.333	7.000	8.000	7.667	4	3	3	7	5	132	207	179	**68**	283	271.0	280.0	2
1948	3	15	5918	5918.5	1571	15	5.667	8.333	8.000	7.333	6.333	7.000	7.667	5.000	67	236	207	154	94	132	179	48	**140**	194	146.1	144.6	2
1948	10	18	6135	6135.5	1579	16	8.333	6.667	5.333	3.667	3.667	4.000	5.333	7.333	236	111	56	22	22	27	56	154	**86**	252	167.4	166.0	2
1949	1	25	6234	6234.5	1583	7	8.667	8.000	6.667	4.333	5.000	6.000	8.333	8.333	300	207	111	32	48	80	236	236	**156**	205	184.9	179.3	2
1949	1	26	6235	6235.5	1583	8	8.333	8.000	7.000	5.667	5.000	5.000	4.667	4.000	236	207	132	67	48	48	39	27	**100**	181	178.4	173.0	2
1949	5	12	6341	6341.5	1587	6	2.000	2.000	7.333	7.333	8.333	8.667	8.333	7.000	7	7	154	154	236	300	236	132	**153**	102	136.8	139.7	2
1949	5	13	6342	6342.5	1587	7	8.000	7.333	3.333	2.000	5.333	3.333	1.000	2.333	207	154	18	7	56	18	4	9	**59**	85	126.1	128.8	2
1949	10	15	6497	6497.5	1592	27	6.000	6.000	7.333	8.000	7.333	7.333	8.333	7.667	80	80	154	207	154	154	236	179	**156**	212	189.0	187.8	2
1950	2	20	6625	6625.5	1597	20	2.333	2.667	1.667	2.333	3.000	5.000	8.667	8.333	9	12	6	9	15	48	300	236	**79**	269	208.6	204.0	2
1950	8	19	6805	6805.5	1604	11	5.667	4.333	5.667	6.333	8.000	8.333	7.667	8.000	67	32	67	94	207	236	179	207	**136**	161	0.0	0.0	2
1950	8	20	6806	6806.5	1604	12	8.333	8.000	7.667	7.667	4.000	3.333	2.333	2.000	236	207	179	179	27	18	9	7	**108**	160	0.0	0.0	2
1951	9	25	7207	7207.5	1619	8	3.667	4.667	4.667	5.333	7.333	7.667	8.000	8.333	22	39	39	56	154	179	207	236	**116**	108	109.6	110.2	2
1951	9	26	7208	7208.5	1619	9	8.667	7.667	4.333	3.667	2.667	3.333	2.333	2.667	300	179	32	22	12	18	9	12	**73**	99	112.1	112.7	2
1951	10	28	7240	7240.5	1620	14	0.333	3.667	3.333	5.333	7.000	8.000	8.667	5.000	2	22	18	56	132	207	300	48	**98**	101	113.3	111.8	2
1952	3	6	7370	7370.5	1625	9	8.000	7.333	6.333	4.667	4.333	4.000	5.000	5.333	207	154	94	39	32	27	48	56	**82**	15	75.8	74.7	2

1952	4	21	7416	7416.5	1627	1	2.667	3.333	4.000	4.000	8.333	8.000	7.000	6.333	12	18	27	27	236	207	132	94	**94**	88	89.3	90.3	2
1952	5	27	7452	7452.5	1628	10	8.000	5.667	4.667	5.333	4.333	5.333	5.667	5.000	207	67	39	56	32	56	67	48	**72**	61	86.7	89.1	2
1952	6	30	7486	7486.5	1629	17	5.333	8.000	7.667	7.000	3.667	2.333	1.667	2.333	56	207	179	132	22	9	6	9	**78**	108	101.9	105.3	2
1956	2	25	8821	8821.5	1679	2	0.667	6.000	8.333	7.333	6.667	6.667	6.667	3.333	3	80	236	154	111	111	111	18	**103**	211	0.0	0.0	2
1956	4	27	8883	8883.5	1681	10	8.667	8.667	7.667	7.667	6.667	6.667	7.000	5.667	300	300	179	179	111	111	132	67	**172**	129	137.1	139.0	2
1956	5	16	8902	8902.5	1682	2	5.333	7.333	7.667	7.000	8.333	7.667	7.000	7.667	56	154	179	132	236	179	132	179	**156**	173	156.0	159.6	2
1956	9	2	9011	9011.5	1686	3	5.000	7.667	8.000	6.667	4.667	4.000	4.000	3.000	48	179	207	111	39	27	27	15	**82**	224	179.4	182.5	2
1956	9	8	9017	9017.5	1686	9	1.000	1.000	3.667	5.333	8.333	8.000	6.000	3.333	4	4	22	56	236	207	80	18	**78**	222	203.4	206.3	2
1957	1	21	9152	9152.5	1691	9	1.667	3.333	3.667	3.667	4.667	5.667	7.667	8.667	6	18	22	22	39	67	179	300	**82**	251	226.1	219.0	2
1957	1	22	9153	9153.5	1691	10	8.333	6.667	6.333	4.667	4.000	4.000	3.000	2.333	236	111	94	39	27	27	15	9	**70**	273	228.7	221.6	2
1957	3	2	9192	9192.5	1692	22	6.000	8.333	8.333	7.000	6.667	5.333	6.333	6.667	80	236	236	132	111	56	94	111	**132**	232	183.1	180.0	2
1957	6	30	9312	9312.5	1697	7	3.000	6.333	5.333	7.667	8.000	8.000	8.000	8.333	15	94	56	179	207	207	207	236	**150**	289	265.0	273.9	2
1957	7	2	9314	9314.5	1697	9	1.667	1.000	2.667	4.667	8.000	6.333	5.667	2.333	6	4	12	39	207	94	67	9	**55**	275	242.0	250.2	2
1957	9	3	9377	9377.5	1699	18	6.667	6.333	6.333	7.333	8.000	8.667	6.000	4.667	111	94	94	154	207	300	80	39	**135**	269	273.5	278.1	2
1957	9	4	9378	9378.5	1699	19	3.667	4.667	2.333	2.667	8.333	9.000	8.000	8.333	22	39	9	12	236	400	207	236	**145**	245	247.5	251.6	2
1957	9	5	9379	9379.5	1699	20	8.333	8.667	6.667	5.000	4.667	4.000	5.333	6.000	236	300	111	48	39	27	56	80	**112**	242	237.5	241.3	2
1957	9	13	9387	9387.5	1700	1	7.667	8.333	8.667	8.667	7.000	6.000	4.000	4.000	179	236	300	300	132	80	27	27	**160**	357	268.5	271.7	2
1957	9	23	9397	9397.5	1700	11	8.000	8.667	7.667	7.667	7.667	6.667	6.667	5.000	207	300	179	179	179	111	111	48	**164**	379	295.2	297.1	2
1957	9	29	9403	9403.5	1700	17	4.000	5.333	5.000	4.333	8.000	8.667	8.333	8.000	27	56	48	32	207	300	236	207	**139**	343	257.0	257.7	2
1958	2	11	9538	9538.5	1705	17	9.000	8.333	8.667	8.333	8.000	5.333	6.000	6.000	400	236	300	236	207	56	80	80	**199**	242	230.1	224.2	2
1958	5	31	9647	9647.5	1709	18	2.333	4.000	2.000	3.333	4.333	6.333	7.667	8.000	9	27	7	18	32	94	179	207	**72**	256	209.0	214.9	2
1958	6	29	9676	9676.5	1710	20	7.000	8.000	6.667	5.333	7.667	6.333	4.333	2.667	132	207	111	56	179	94	32	12	**103**	283	220.0	227.4	2
1958	7	8	9685	9685.5	1711	2	3.000	2.667	7.333	7.667	8.333	9.000	8.667	8.667	15	12	154	179	236	400	300	300	**200**	290	232.0	239.8	2
1958	9	4	9743	9743.5	1713	6	5.000	4.333	3.333	3.667	7.333	8.667	8.333	8.333	48	32	18	22	154	300	236	236	**131**	340	256.5	260.8	2
1958	9	5	9744	9744.5	1713	7	8.000	7.667	4.333	4.000	3.333	3.667	5.667	3.000	207	179	32	27	18	22	67	15	**71**	292	233.5	237.3	2
1959	3	27	9947	9947.5	1720	21	7.333	7.667	8.333	6.667	8.333	8.333	7.667	6.333	154	179	236	111	236	236	179	94	**178**	252	246.7	245.7	2
1959	5	12	9993	9993.5	1722	13	7.000	6.667	6.667	5.667	6.667	8.333	5.333	4.667	132	111	111	67	111	236	56	39	**108**	**391**	266.3	271.8	2
1959	7	15	10057	10057.5	1724	23	4.333	5.000	8.000	8.667	8.667	9.000	8.667	8.667	32	48	207	300	300	400	300	300	**236**	249	245.0	253.1	2
1959	7	17	10059	10059.5	1724	25	3.333	4.333	3.333	3.667	3.333	8.333	8.667	8.333	18	32	18	22	18	236	300	236	**110**	273	240.0	247.9	2
1959	7	18	10060	10060.5	1724	26	8.000	7.667	8.000	5.667	4.667	7.000	4.667	6.000	207	179	207	67	39	132	39	80	**119**	276	231.0	238.6	2
1959	8	16	10089	10089.5	1726	1	4.333	4.333	6.667	7.333	8.333	8.000	6.667	7.333	32	32	111	154	236	207	111	154	**130**	222	201.2	206.3	2
1959	8	17	10090	10090.5	1726	2	7.667	8.333	6.667	6.333	5.333	7.000	5.000	5.333	179	236	111	94	56	132	48	56	**114**	235	224.2	229.8	2
1959	11	28	10193	10193.5	1729	24	6.000	8.000	7.333	6.667	4.333	3.667	4.000	4.000	80	207	154	111	32	22	27	27	**82**	214	230.2	224.0	2
1960	3	31	10317	10317.5	1734	13	4.333	4.667	5.000	7.667	6.667	8.000	7.667	8.333	32	39	48	179	111	207	179	236	**129**	187	182.5	182.3	2
1960	4	1	10318	10318.5	1734	14	8.667	8.667	7.000	8.000	8.333	8.667	8.667	7.333	300	300	132	207	236	300	300	154	**241**	218	201.4	201.3	2
1960	4	30	10347	10347.5	1735	16	6.667	6.667	5.667	5.667	8.667	9.000	8.000	7.000	111	111	67	67	300	400	207	132	**174**	142	161.2	163.7	2
1960	5	8	10355	10355.5	1735	24	3.333	6.333	6.667	7.333	8.000	8.333	6.333	6.667	18	94	111	154	207	236	94	111	**128**	191	168.2	171.4	2
1960	7	15	10423	10423.5	1738	11	3.000	3.667	3.667	5.000	6.333	7.333	7.667	8.000	15	22	22	48	94	154	179	207	**93**	149	146.0	150.8	2
1960	7	16	10424	10424.5	1738	12	8.333	6.667	5.667	5.000	4.333	5.333	4.667	4.000	236	111	67	48	32	56	39	27	**77**	187	144.0	148.8	2
1960	9	4	10474	10474.5	1740	8	3.667	4.667	6.667	6.000	6.667	6.000	6.667	8.000	22	39	111	80	111	80	111	207	**95**	106	142.3	144.6	2
1960	10	6	10506	10506.5	1741	13	6.000	8.000	7.333	8.000	8.000	8.333	8.333	8.667	80	207	154	207	207	236	236	300	**203**	130	132.7	132.5	2
1960	10	7	10507	10507.5	1741	14	9.000	8.667	7.667	7.667	7.333	7.000	5.667	6.000	400	300	179	179	154	132	67	80	**186**	160	144.7	144.4	2
1960	11	12	10543	10543.5	1742	23	2.000	1.000	2.000	1.667	5.000	6.000	7.667	8.000	7	4	7	6	48	80	179	207	**67**	164	169.8	166.3	2
1960	11	13	10544	10544.5	1742	24	8.667	8.667	9.000	9.000	8.667	8.333	8.000	6.333	300	300	400	400	300	236	207	94	**280**	173	182.0	178.1	2
1960	12	1	10562	10562.5	1743	15	6.333	8.000	6.667	5.000	5.333	6.000	5.667	6.000	94	207	111	48	56	80	67	80	**93**	105	138.2	134.3	2
1961	7	13	10786	10786.5	1751	23	0.333	1.000	0.667	6.333	8.000	8.333	7.667	6.333	2	4	3	94	207	236	179	94	**102**	122	141.0	145.7	2
1961	7	14	10787	10787.5	1751	24	4.667	3.000	6.667	8.333	7.333	6.667	6.333	4.000	39	15	111	236	154	111	94	27	**98**	160	136.0	140.5	2
1961	7	27	10800	10800.5	1752	10	4.000	4.333	8.333	8.333	6.000	5.333	6.333	7.333	27	32	236	236	80	56	94	154	**114**	75	111.0	114.4	2
1961	9	30	10865	10865.5	1754	21	2.000	3.000	1.667	1.667	2.000	0.333	4.667	8.000	7	15	6	6	7	2	39	207	**36**	74	100.4	100.6	2
1961	10	1	10866	10866.5	1754	22	8.667	8.333	7.000	7.667	4.667	2.000	2.000	2.333	300	236	132	179	39	7	7	9	**114**	64	98.4	98.6	2
1961	10	28	10893	10893.5	1755	22	2.333	2.333	5.000	6.333	8.000	8.000	8.667	7.333	9	9	48	94	207	207	300	154	**128**	12	86.6	85.4	2
1963	9	22	11587	11587.5	1781	14	4.333	8.333	7.667	4.667	4.000	4.667	7.333	8.667	32	236	179	39	27	39	154	300	**126**	99	105.4	106.2	2
1963	9	23	11588	11588.5	1781	15	8.667	8.000	4.333	4.333	3.333	3.333	3.000	1.667	300	207	32	32	18	18	15	6	**78**	76	99.2	99.9	2
1963	10	29	11624	11624.5	1782	24	3.333	2.667	2.333	1.667	4.000	7.000	7.667	8.000	18	12	9	6	27	132	179	207	**74**	76	85.5	84.3	2
1966	9	3	12664	12664.5	1821	11	3.000	3.333	3.667	5.667	6.000	6.000	7.333	8.667	15	18	22	67	80	80	154	300	**92**	36	101.5	103.2	2
1966	9	4	12665	12665.5	1821	12	8.667	8.333	7.333	6.000	5.667	4.000	3.333	3.000	300	236	154	80	67	27	18	15	**112**	26	100.2	101.9	2
1967	2	16	12830	12830.5	1827	15	3.667	3.333	5.000	8.000	7.000	4.000	4.667	3.667	22	18	48	207	132	27	39	22	**64**	85	128.0	125.0	2
1967	5	25	12928	12928.5	1831	5	1.667	2.000	1.000	5.333	8.333	7.333	7.667	9.000	6	7	4	56	236	154	179	400	**130**	232	205.4	210.7	2
1967	5	26	12929	12929.5	1831	6	9.000	8.667	7.333	6.667	6.667	3.667	4.000	4.667	400	300	154	111	111	22	27	39	**146**	246	213.2	218.8	2
1967	6	6	12940	12940.5	1831	17	8.000	5.000	2.000	1.667	2.333	2.000	4.333	5.000	207	48	7	6	9	7	32	48	**46**	113	126.7	130.5	2

1968	6	11	13311	13311.5	1845	10	7.000	8.000	7.000	6.333	6.667	5.000	5.667	4.333	132	207	132	94	111	48	67	32	**103**	123	142.1	146.5	2
1968	10	31	13453	13453.5	1850	17	4.667	4.333	5.000	7.333	8.000	8.000	7.000	6.000	39	32	48	154	207	207	132	80	**112**	140	161.9	159.5	2
1968	11	1	13454	13454.5	1850	18	5.333	3.000	2.667	6.000	8.333	8.000	7.000	8.333	56	15	12	80	236	207	132	236	**122**	126	155.7	153.3	2
1969	2	2	13547	13547.5	1854	3	0.000	0.000	1.667	2.000	2.000	4.667	8.000	6.667	0	0	6	7	7	39	207	111	**47**	136	143.2	139.1	2
1969	3	24	13597	13597.5	1855	26	8.000	6.333	6.667	7.000	5.333	3.333	1.667	1.667	207	94	111	132	56	18	6	6	**79**	207	196.6	195.5	2
1969	9	30	13787	13787.5	1862	27	8.000	7.000	6.333	6.667	6.000	4.000	5.333	2.667	207	132	94	111	80	27	56	12	**90**	140	136.6	136.9	2
1970	3	8	13946	13946.5	1868	24	4.333	5.000	5.667	5.000	7.333	8.000	9.000	8.333	32	48	67	48	154	207	400	236	**149**	167	175.3	172.8	2
1970	4	21	13990	13990.5	1870	14	3.667	4.000	5.000	5.667	6.000	6.667	8.333	7.000	22	27	48	67	80	111	236	132	**90**	91	125.0	126.3	2
1970	8	17	14108	14108.5	1874	24	5.333	8.667	8.000	6.000	5.333	6.667	5.333	5.333	56	300	207	80	56	111	56	56	**115**	140	147.9	151.6	2
1970	12	14	14227	14227.5	1879	8	3.667	6.000	8.333	5.000	4.333	3.000	4.333	5.333	22	80	236	48	32	15	32	56	**65**	120	159.5	154.5	2
1972	6	18	14779	14779.5	1899	20	8.333	7.333	7.000	6.333	7.000	7.333	6.000	4.000	236	154	132	94	132	154	80	27	**126**	135	144.2	148.9	2
1972	8	4	14826	14826.5	1901	13	5.667	8.333	7.000	4.000	5.333	4.000	6.667	9.000	67	236	132	27	56	27	111	400	**132**	120	141.9	146.0	2
1972	8	5	14827	14827.5	1901	14	8.333	8.333	7.000	7.333	7.667	8.667	7.333	5.667	236	236	132	154	179	300	154	67	**182**	132	142.4	146.5	2
1972	8	9	14831	14831.5	1901	18	4.667	6.667	6.667	8.333	4.000	4.333	3.333	3.333	39	111	111	236	27	32	18	18	**74**	84	120.4	123.7	2
1972	9	14	14867	14867.5	1902	27	6.667	8.000	4.667	1.333	1.667	3.333	4.000	3.333	111	207	39	5	6	18	27	18	**54**	52	98.2	99.3	2
1972	11	1	14915	14915.5	1904	21	7.667	8.000	7.667	6.333	5.333	2.000	4.667	4.000	179	207	179	94	56	7	39	27	**98**	106	131.9	129.9	2
1973	4	1	15066	15066.5	1910	10	4.000	2.667	3.000	4.000	5.333	7.667	8.333	7.667	27	12	15	27	56	179	236	179	**91**	92	115.1	115.0	2
1974	7	6	15527	15527.5	1927	12	6.667	8.333	8.667	6.000	7.333	6.333	5.000	3.000	111	236	300	80	154	94	48	15	**130**	132	117.5	121.5	2
1974	9	16	15599	15599.5	1930	3	8.000	7.667	6.000	6.667	6.333	2.667	2.667	2.000	207	179	80	111	94	12	12	7	**88**	96	100.9	102.0	2
1976	3	26	16156	16156.5	1950	20	4.333	7.333	8.000	7.333	8.000	8.000	7.000	5.667	32	154	207	154	207	207	132	67	**145**	54	84.5	84.1	2
1976	4	1	16162	16162.5	1950	26	6.333	8.333	8.333	8.333	6.000	4.333	3.333	2.667	94	236	236	236	80	32	18	12	**118**	33	79.7	79.6	2
1976	5	3	16194	16194.5	1952	4	8.333	7.667	6.667	7.000	5.333	4.333	3.667	2.333	236	179	111	132	56	32	22	9	**97**	36	70.7	71.9	2
1978	4	30	16921	16921.5	1979	2	3.333	2.667	2.000	5.000	6.667	8.000	3.667	4.667	18	12	7	48	111	207	22	39	**58**	106	179.4	182.1	2
1978	5	1	16922	16922.5	1979	3	2.667	4.667	5.667	5.333	7.333	4.333	6.667	8.333	12	39	67	56	154	32	111	236	**88**	120	178.5	181.3	2
1978	7	4	16986	16986.5	1981	13	6.000	3.667	4.000	4.000	7.667	8.000	3.667	6.000	80	22	27	27	179	207	22	80	**80**	68	113.5	117.3	2
1978	8	28	17041	17041.5	1983	14	4.333	7.333	8.333	7.667	8.000	6.333	4.667	5.000	32	154	236	179	207	94	39	48	**124**	81	105.6	107.7	2
1978	9	29	17073	17073.5	1984	19	4.333	6.667	7.667	8.000	8.000	6.667	3.667	1.667	32	111	179	207	207	111	22	6	**109**	173	147.7	148.2	2
1979	4	3	17259	17259.5	1991	16	3.000	2.333	2.667	2.667	2.667	5.333	6.667	8.000	15	9	12	12	12	56	111	207	**54**	191	194.2	194.2	2
1979	4	25	17281	17281.5	1992	11	7.667	8.000	7.667	7.000	7.000	5.000	5.667	5.667	179	207	179	132	132	48	67	67	**126**	120	170.5	172.6	2
1981	4	13	18000	18000.5	2019	1	8.000	8.333	7.667	5.667	6.333	5.667	5.667	5.000	207	236	179	67	94	67	67	48	**121**	284	253.4	254.9	2
1981	7	25	18103	18103.5	2022	23	4.333	5.667	6.667	4.333	8.333	8.333	7.667	7.667	32	67	111	32	236	236	179	179	**134**	304	251.6	259.5	2
1981	7	26	18104	18104.5	2022	24	8.000	6.667	6.000	5.000	5.667	5.667	4.000	3.333	207	111	80	48	67	67	27	18	**78**	294	264.6	272.9	2
1982	3	1	18322	18322.5	2030	26	2.333	2.333	3.333	4.667	6.333	7.000	4.667	8.000	9	9	18	39	94	132	39	207	**68**	242	235.5	231.3	2
1982	3	2	18323	18323.5	2030	27	8.000	7.667	6.667	7.333	6.000	5.333	4.667	4.000	207	179	111	154	80	56	39	27	**107**	250	232.2	228.2	2
1982	7	13	18456	18456.5	2035	25	4.667	5.667	5.000	4.333	4.333	8.333	8.667	9.000	39	67	48	32	32	236	300	400	**144**	288	244.5	252.7	2
1982	7	14	18457	18457.5	2035	26	9.000	7.667	6.667	7.000	6.000	7.000	6.667	6.000	400	179	111	132	80	132	111	80	**153**	292	260.6	269.3	2
1982	9	6	18511	18511.5	2037	26	8.000	8.333	8.333	8.333	8.667	7.333	7.000	6.333	207	236	236	236	300	154	132	94	**199**	199	169.4	172.1	2
1982	9	22	18527	18527.5	2038	15	7.667	8.333	8.000	7.667	6.667	6.000	4.333	5.333	179	236	207	179	111	80	32	56	**135**	134	145.2	146.2	2
1983	1	10	18637	18637.5	2042	17	7.333	8.333	7.000	5.000	3.333	2.667	2.333	3.000	154	236	132	48	18	12	9	15	**78**	114	149.1	144.2	2
1983	2	5	18663	18663.5	2043	16	7.333	8.000	7.333	7.333	7.333	6.000	7.000	6.667	154	207	154	154	154	80	132	111	**143**	118	158.7	154.3	2
1983	5	24	18771	18771.5	2047	16	4.000	4.000	3.000	2.667	4.667	8.000	7.667	6.667	27	27	15	12	39	207	179	111	**77**	148	136.9	140.4	2
1984	11	16	19313	19313.5	2067	18	7.667	8.000	7.000	6.667	6.333	5.333	5.667	5.000	179	207	132	111	94	56	67	48	**112**	13	72.3	70.7	2
1985	4	21	19469	19469.5	2073	12	8.333	7.333	8.000	5.667	4.667	5.667	4.333	3.667	236	154	207	67	39	67	32	22	**103**	21	77.1	77.9	2
1986	2	8	19762	19762.5	2084	8	7.000	7.000	7.333	6.667	8.000	7.667	9.000	8.667	132	132	154	111	207	179	400	300	**202**	65	96.9	94.3	2
1986	2	9	19763	19763.5	2084	9	8.667	7.667	5.333	4.667	5.000	6.333	5.333	4.000	300	179	56	39	48	94	56	27	**100**	56	95.1	92.6	2
1986	9	12	19978	19978.5	2092	8	5.333	8.667	7.333	5.667	4.333	4.000	4.667	4.667	56	300	154	67	32	27	39	39	**89**	0	67.9	68.8	2
1988	4	3	20547	20547.5	2113	10	2.667	2.667	5.000	4.667	1.667	4.333	8.000	4.333	12	12	48	39	6	32	207	32	**48**	116	127.6	127.6	2
1989	3	13	20891	20891.5	2126	3	6.000	7.667	8.667	8.333	8.333	8.333	8.667	9.000	80	179	300	236	236	236	300	400	**246**	210	256.0	253.0	2
1989	3	14	20892	20892.5	2126	4	9.000	7.667	7.667	5.667	5.000	5.333	7.667	7.333	400	179	179	67	48	56	179	154	**158**	235	266.7	263.8	2
1989	9	19	21081	21081.5	2133	4	6.667	8.000	7.000	5.000	4.000	3.000	2.667	1.333	111	207	132	48	27	15	12	5	**70**	194	195.3	197.0	2
1989	10	20	21112	21112.5	2134	8	2.333	3.000	4.333	6.667	7.667	7.667	8.333	7.000	9	15	32	111	179	179	236	132	**112**	186	207.3	205.4	2
1989	10	21	21113	21113.5	2134	9	6.333	6.667	7.000	8.333	7.667	6.667	8.000	6.333	94	111	132	236	179	111	207	94	**146**	202	208.2	206.2	2
1989	11	17	21140	21140.5	2135	9	3.667	3.000	4.000	7.000	6.667	7.667	8.000	7.667	22	15	27	132	111	179	207	179	**109**	171	220.0	215.0	2
1990	4	10	21284	21284.5	2140	18	4.000	5.333	7.000	7.667	8.000	7.333	7.333	6.000	27	56	132	179	207	154	154	80	**124**	111	148.7	149.3	2
1990	6	12	21347	21347.5	2142	27	4.000	3.000	4.333	4.333	5.333	7.000	7.667	8.333	27	15	32	32	56	132	179	236	**89**	167	215.1	221.8	2
1991	3	24	21632	21632.5	2153	15	3.000	8.667	8.000	7.333	5.333	5.000	8.000	8.667	15	300	207	154	56	48	207	300	**161**	214	262.0	260.5	2
1991	3	25	21633	21633.5	2153	16	7.667	8.667	5.000	6.000	7.667	5.667	5.333	7.000	179	300	48	80	179	67	56	132	**130**	203	236.5	235.2	2
1991	3	26	21634	21634.5	2153	17	7.000	7.333	7.000	6.667	8.000	6.000	5.333	4.667	132	154	132	111	207	80	56	39	**114**	212	230.5	229.4	2
1991	6	5	21705	21705.5	2156	7	6.667	7.333	8.000	8.000	8.000	8.667	8.000	7.667	111	154	207	207	207	300	207	179	**196**	238	250.7	258.1	2
1991	7	8	21738	21738.5	2157	13	2.333	2.667	3.667	4.333	4.667	8.000	7.333	5.667	9	12	22	32	39	207	154	67	**68**	281	204.3	211.2	2

1991	7	9	21739	21739.5	2157	14	3.333	4.667	8.000	7.000	8.000	7.333	6.667	5.667	18	39	207	132	207	154	111	67	**117**	248	194.1	200.6	2
1991	7	13	21743	21743.5	2157	18	4.667	5.000	6.667	7.000	8.000	8.667	6.000	7.333	39	48	111	132	207	300	80	154	**134**	192	195.7	202.3	2
1991	10	28	21850	21850.5	2161	17	5.333	5.333	4.667	6.333	7.667	8.333	5.333	5.667	56	56	39	94	179	236	56	67	**98**	302	271.0	267.5	2
1991	10	29	21851	21851.5	2161	18	7.667	8.333	8.000	6.333	4.667	6.000	7.000	5.333	179	236	207	94	39	80	132	56	**128**	339	272.5	268.8	2
1991	11	1	21854	21854.5	2161	21	5.333	3.333	5.333	5.333	6.667	8.000	8.333	7.000	56	18	56	56	111	207	236	132	**109**	292	230.2	226.8	2
1991	11	8	21861	21861.5	2162	1	2.667	3.000	4.000	4.000	6.667	6.667	7.667	8.667	12	15	27	27	111	111	179	300	**98**	208	200.4	196.7	2
1991	11	9	21862	21862.5	2162	2	8.333	8.333	7.333	6.667	6.000	5.000	5.333	4.333	236	236	154	111	80	48	56	32	**119**	195	197.4	193.6	2
1992	2	26	21971	21971.5	2166	3	3.333	3.333	3.667	3.667	4.000	6.333	8.000	6.667	18	18	22	22	27	94	207	111	**65**	281	252.9	248.0	2
1992	5	10	22045	22045.5	2168	23	5.333	6.333	8.000	8.667	8.333	7.667	8.000	7.333	56	94	207	300	236	179	207	154	**179**	93	124.4	126.9	2
1992	8	23	22150	22150.5	2172	20	7.667	8.000	6.333	3.000	4.333	2.333	4.000	3.667	179	207	94	15	32	9	27	22	**73**	51	110.7	113.2	2
1994	4	17	22752	22752.5	2195	1	6.667	8.333	8.333	7.000	4.667	3.000	3.000	3.333	111	236	236	132	39	15	15	18	**100**	29	81.8	82.5	2
1995	4	7	23107	23107.5	2208	5	4.000	5.667	6.000	5.333	7.000	8.000	7.333	6.000	27	67	80	56	132	207	154	80	**100**	0	70.5	70.7	2
1996	10	23	23672	23672.5	2229	3	7.333	5.667	3.667	3.333	1.667	3.000	2.333	2.000	154	67	22	18	6	15	9	7	**37**	0	70.5	69.8	2
1998	5	4	24230	24230.5	2249	21	6.000	8.667	8.333	5.667	6.000	3.667	2.333	3.000	80	300	236	67	80	22	9	15	**101**	96	121.1	123.2	2
1998	8	27	24345	24345.5	2254	1	8.000	8.000	7.667	6.667	6.667	6.667	7.000	6.333	207	207	179	111	111	111	132	94	**144**	131	135.0	137.8	2
1998	9	25	24374	24374.5	2255	3	7.667	8.000	8.333	7.000	6.333	5.667	2.667	2.333	179	207	236	132	94	67	12	9	**117**	149	138.5	139.2	2
1999	9	22	24736	24736.5	2268	14	3.000	2.000	2.000	2.667	5.000	3.667	6.000	8.000	15	7	7	12	48	22	80	207	**50**	89	140.4	141.5	2
1999	10	22	24766	24766.5	2269	17	7.000	7.667	8.000	5.333	4.667	4.333	5.667	3.333	132	179	207	56	39	32	67	18	**91**	124	160.3	158.8	2
2000	4	6	24933	24933.5	2275	22	1.667	4.333	2.667	2.333	3.333	6.667	8.333	8.333	6	32	12	9	18	111	236	236	**82**	165	177.7	178.1	2
2000	4	7	24934	24934.5	2275	23	8.667	6.000	6.000	4.000	4.000	4.333	3.667	3.667	300	80	80	27	27	32	22	22	**74**	143	174.9	175.4	2
2000	5	24	24981	24981.5	2277	16	8.000	7.667	6.000	5.667	5.000	5.000	6.000	4.333	207	179	80	67	48	48	80	32	**93**	183	189.4	194.3	2
2000	7	15	25033	25033.5	2279	14	3.000	3.667	4.667	4.333	8.000	8.667	9.000	8.667	15	22	39	32	207	300	400	300	**164**	213	213.1	220.1	2
2000	9	17	25097	25097.5	2281	24	4.667	4.000	2.333	3.000	4.000	4.667	5.333	8.333	39	27	9	15	27	39	56	236	**56**	154	181.5	183.2	2
2001	3	31	25292	25292.5	2289	3	6.667	8.667	8.667	6.333	7.000	8.000	8.333	7.333	111	300	300	94	132	207	236	154	**192**	300	245.6	245.3	2
2001	4	11	25303	25303.5	2289	14	3.000	2.333	2.000	2.000	3.667	8.000	7.667	8.333	15	9	7	7	22	207	179	236	**85**	173	159.6	160.3	2
2001	11	6	25512	25512.5	2297	7	8.667	8.667	7.000	5.000	5.333	6.667	6.333	6.333	300	300	132	48	56	111	94	94	**142**	232	237.4	233.2	2
2001	11	24	25530	25530.5	2297	25	3.333	5.333	8.333	7.000	7.667	7.333	3.000	4.667	18	56	236	132	179	154	15	39	**104**	111	173.0	168.6	2
2002	5	23	25710	25710.5	2304	16	2.667	2.667	2.000	6.667	7.667	8.333	5.000	3.333	12	12	7	111	179	236	48	18	**78**	211	180.3	184.8	2
2003	5	29	26081	26081.5	2318	9	4.000	3.667	3.667	3.000	7.000	7.667	8.333	8.333	27	22	22	15	132	179	236	236	**109**	89	137.8	141.6	2
2003	10	29	26234	26234.5	2323	27	4.667	4.000	9.000	8.000	7.667	7.667	8.667	8.667	39	27	400	207	179	179	300	300	**204**	250	291.7	287.7	2
2003	10	30	26235	26235.5	2324	1	8.667	7.333	5.333	4.667	5.000	7.000	9.000	9.000	300	154	56	39	48	132	400	400	**191**	250	271.4	267.6	2
2003	10	31	26236	26236.5	2324	2	8.333	7.667	7.333	6.667	7.333	4.667	4.000	4.333	236	179	154	111	154	39	27	32	**116**	239	248.9	245.2	2
2003	11	4	26240	26240.5	2324	6	3.000	3.000	6.333	7.000	2.667	2.000	3.333	2.667	15	15	94	132	12	7	18	12	**38**	64	560.9	551.6	2
2003	11	20	26256	26256.5	2324	22	1.000	3.667	6.333	6.333	7.667	8.667	8.667	8.000	4	22	94	94	179	300	300	207	**150**	111	175.2	171.0	2
2004	7	25	26504	26504.5	2333	27	7.000	7.333	6.333	7.667	7.333	8.000	7.333	7.333	132	154	94	179	154	207	154	154	**154**	94	156.2	161.1	2
2004	7	27	26506	26506.5	2334	2	8.333	7.667	7.333	8.000	8.667	8.333	6.333	6.000	236	179	154	207	300	236	94	80	**186**	90	118.1	121.8	2
2004	11	7	26609	26609.5	2337	24	1.667	3.000	0.667	3.333	3.000	4.667	6.333	8.000	6	15	3	18	15	39	94	207	**50**	101	129.6	127.2	2
2004	11	8	26610	26610.5	2337	25	8.667	8.667	8.333	7.000	5.000	2.667	4.333	5.333	300	300	236	132	48	12	32	56	**140**	92	124.1	121.7	2
2004	11	9	26611	26611.5	2337	26	5.667	6.000	5.000	6.000	7.000	6.667	8.667	7.000	67	80	48	80	132	111	300	132	**119**	84	140.9	138.1	2
2004	11	10	26612	26612.5	2337	27	7.667	8.333	8.667	8.333	7.333	6.333	5.333	4.333	179	236	300	236	154	94	56	32	**161**	52	104.6	102.6	2
2005	1	21	26684	26684.5	2340	18	3.333	2.000	2.333	2.333	2.667	6.667	8.000	7.333	18	7	9	9	12	111	207	154	**66**	69	113.5	109.9	2
2005	5	8	26791	26791.5	2344	17	6.000	5.333	3.667	6.000	8.333	7.667	5.333	3.667	80	56	22	80	236	179	56	22	**91**	67	101.3	103.2	2
2005	5	15	26798	26798.5	2344	24	5.667	5.667	8.333	7.667	4.000	4.000	5.000	5.000	67	67	236	179	27	27	48	48	**87**	56	103.0	105.2	2
2005	8	24	26899	26899.5	2348	17	2.667	3.333	6.333	8.667	7.333	6.667	6.333	4.333	12	18	94	300	154	111	94	32	**102**	70	98.6	100.7	2
2005	9	11	26917	26917.5	2349	8	6.333	7.000	7.667	6.333	7.000	5.333	6.000	4.667	94	132	179	94	132	56	80	39	**101**	58	109.7	111.1	2
2006	12	15	27377	27377.5	2366	9	8.333	7.667	6.667	5.667	6.000	4.000	4.000	3.667	236	179	111	67	80	27	27	22	**94**	21	88.2	85.4	2
2012	3	9	29288	29288.5	2437	3	4.667	6.333	8.000	7.333	6.667	5.667	3.000	2.333	39	94	207	154	111	67	15	9	**87**	110	145.5	143.5	2
2015	3	17	30391	30391.5	2477	26	2.000	4.667	5.667	5.333	7.667	7.667	7.333	7.667	7	39	67	56	179	179	154	179	**108**	38	114.3	113.2	2
2015	6	22	30488	30488.5	2481	15	1.000	3.333	4.333	3.000	4.667	5.333	8.333	5.333	4	18	32	15	39	56	236	56	**57**	56	246.9	255.0	2
2017	9	8	31297	31297.5	2511	14	8.000	4.667	4.333	5.000	8.333	7.333	6.333	4.667	207	39	32	48	236	154	94	39	**106**	88	116.8	118.5	2
2021	11	4	32815	32815.5	2567	20	6.333	5.667	7.000	7.667	5.667	3.667	1.667	2.000	94	67	132	179	67	22	6	7	**72**	28	92.4	90.8	2
2023	2	27	33295	33295.5	2585	14	5.000	6.000	6.667	6.667	6.333	6.667	6.333	6.000	48	80	111	111	94	111	94	80	**91**	127	161.2	158.1	1
2023	3	24	33320	33320.5	2586	12	7.333	8.000	6.333	4.000	2.333	3.667	4.667	4.333	154	207	94	27	9	22	39	32	**73**	146	157.5	156.6	1
2023	4	23	33350	33350.5	2587	15	2.333	1.667	1.333	3.333	4.667	5.333	8.333	7.333	9	6	5	18	39	56	236	154	**65**	80	135.2	136.7	1
2023	4	24	33351	33351.5	2587	16	6.667	8.000	7.000	5.667	3.667	3.000	2.333	3.000	111	207	132	67	22	15	9	15	**72**	72	133.9	135.5	1

Ap - quiet period
(2006 – 2023)

Since 2006 only two days with an Ap-value slightly > 100 occured !!

Appendix 6-C : **Table 3** : List of Geo-magnetic Storms in the time period 1800 – 2023 , mainly based on observational reports (visible Auroras etc.)

Year	month-day(s)	DST-value (in nT)	-dH (nT) from Kakioka	Solar Flare class	Kp-index (before 1932 estimated)	Aurora oval visibility overhead/low-latitute (estimated)	Aurora observation reported from these locations	Effects of solarstorm	Comments	weblinks (more info)		
1811	12-15				9+	≈35°/≈25° (?)	South-& North-Carolina, Havana/Caribean(?),Jerusalem (?)	**possible connection with the strong M7.4-8.6 intraplate-Earthquake** in **New Madrid/Missouri** (USA) on **16-12-1811**	from distant cities & ships (in the Tropics) a Red-Aurora was seen in the night-sky, **one day before the big Earthquake**	more info (page 46)	more info2 (see Light)	
1826	3-29				9-	≤50° / ≤40°	Manchester		rainbow-like arc aurora, stretching across the midheaven	more info	-	
1827	9-25				9-	≤50° / ≤40°	Charleston, Norfolk, Switzerland Holland, Paris		btilliant bright arc aurora was visible in the northern sky in Charleston, aurora also seen in Central Europe	more info	more info2	
1842	2-24				≈8	≈50° / ≈40°	Alford (Lincolnshire) UK		brilliant aurora with streamers seen in Alford	more info	-	
1843	4-19				9+	≤ 45°/≈23°	Mexico, Scottland	magnetic disturbances measured in Makerstoun Scottland	sporadic aurora observed in Mexico on 19 April 1843 other bright aurora seen on March 20&28 in Manchester	more info	more info2	
1845	12-29				9-	≤50° / ≤40°	Valencia (Spain)		sporadic red aurora observed in Spain on 29 December 1845	more info		
1847	10-24 11-17				9 (24.10)	≤45° / ≈35°	San Fernando (Spain) Cambridge (UK) - 17.11.	strong magnetic storm reported from Helsinki (23/24.10) at the same time great magnetic disturbances (17.11.)	extraordinary display of aurora borealis observed in Cambridge	more info	more info2	
1848	10-18 11-17	-900 (28.8.)			9	≈45° / ≈35°	Valladolid (Spain) - 18.10. Cartagena, Coruna (Spain),UK 17.11.	strong magnetic storm reported from Helsinki (17/18.11) value of a geomag. Storm from 28/29.8.1848 : -900nT	red bright aurora in NNW, color became white later (18.10.) Aurora arc from NNW to NNE, colors: white, green, yellow 17.11.	more info	more info2	more info3
1859	8-28 9-2 to 9-4	-1760			9+	41° / 20°	Hawaii, Cuba, Mexico, Italy, Washington, London	disabled telegraph network from New York to Washington brilliant radiations of different colored light filled the sky	**"Carrington Event"**, big floods of 1861-62 in California indicate: a strong El Nino may have been caused by the solar-storm !	more info	more info2	
1862	12-14				9+	≤44°/≤34°	Virginia, Gulf States (USA)		brilliant aurora borealis seen by civil war soldiers in Virginia possible bright aurora with streamers seen in the gulf states	weblink1	-	
1870	10 -14 & 24				9-	≈45° / ≈35°	New York, Cleveland, Cincinnati (24.10.)	magn. disturbance reported from Melbourne Observatory (Australia) and on other places in the north. Hemisphere	unusual bright and brillant aurora was observed on 24.10. in Cleveland & Cincinnati. It lasted two days !	weblink1	-	
1872	2-4/5	-830			9+	≤45°/≤21° - north ?/23° (?)-south	Paris, Havana, Cuba Rio de Janero (4.2.)		A possible case of a low latitude **sporadic aurora** another bright aurora was visible on 18.8.1872	weblink1	more info	more info3
1872	8-18				**9-**	≤45°/≤35°	New York		the best auroral display that occured in the present generation	weblink1	-	-
1875	Sept.						Martinique Island (magnetic Phenomena observed)	the telegraph chief at Fort de France/Martinique observed that **each of the Sept. 1875 earthquakes was preceded by a marked disturbance of the electric telegraph needles**		more info	-	
1877	5-28				9-	≤45°/≤35°	New York	telegraph lines were effected from Boston, Baltimore, Philadelphia & Washington DC	bright wavering aroras with streamers seen in New York arched aurora that moved halfway to the zenith, visible in NY	weblink1	-	
1880	8-12				≥8	≈50° / ≈40°	daytime aurora borealis in USA	disruption of telegraph-lines in Connecticut/USA	Current was induced in lines. Batteries had to be removed.	weblink1	-	
1882	4-16/17 11-17/18				9+ **≈9**	42°/≈30° - north ≈40°/30° - south	overhead in Chicago & Goulburn/AU England: aurora crossed sky (16/17.4)	strong disruption of telegraph systems, Telegraph lines between Chicago & Milwaukee worked without batteries	a moon-like aurora crossed sky in England, bright aurora of crimson (red) color seen 60° high in Goulburn/NSW Australia	more info	weblink1	more info2
1892	2-13				9-	≈45°/≈35°	Cleveland, Lousville, Detroit, Milwaukee		Was described as the -most wonderful exposition- ever seen on american soil, visible from Iowa to the Atlantic-coast	weblink1	-	-
1897	4-23 / 7-30 8-19 / 12-20				≈8	≈50° / ≈40°	Williams Bay (USA)	**Note**: a telegraph operator noticed 22.5.1897 **a few seconds before an earthquake an unusual signal** on a telegraph device	bright aurora arcs with streamers observed at the Yerkes-Observatory in Williams-Bay (USA) 23.4, 30.7, 19.8. & 20.12.	more info (page1-2)	more info2 (earthquake)	
1898	9-9 & 9-10				≈8	≈50° / ≈40°	reported from Haslemere (UK) Williams-Bay (USA)	disruption of telegraph systems reported from Chicago, Tennessee, Washington by daytime-aurora, Tennessee and Omaha (USA) --> daytime aurora	voltage of ≈ 280 V was induced into the telegraph wires very bright auroras with streamers reported from UK 9.9/10.9. other bright auroras at Williams Bay on 16.1., 14.3, 3.5, 2-15.9.	more info	more info2 (page2-4)	
1899	2-11&15 / 5-1 6-28&29				≈8	≈50° / ≈40°	Williams Bay (USA)		bright aurora arcs with streamers observed at the Yerkes-Observatory in Williams-Bay (USA) 11+15.2, 1.5., 28+29.6.	more info (page5-6)	-	
1901	9-10 9-26				≈6	≈60° / ≈52°	Scottland (10. Sept 1901), Canada, Finnland	Remark : The worldwide hot climate in 1901 may indicate an El Nino event in 1901-02	beautiful display of curtains of Aurora borealis observed in Rusness/Sanday near Kirkwall (Nature Journal No. 1665)	more info		
1902	Oct.				9-	≤50° / ≤40°	Spain (Pyrenees mountains)		pink & red Aurora observed on a few occations	more info		
1903	≈10-30 11-1 (& 7-29)	-531			9+	**≤44°/≤34° (north)** ≈35°/≤30° (south)	Ireland, Scottland, Chicago, Colorado, overhead Aurora in Duluth & NSW-Australia	disruption of Western Union- & New York telegraph systems & transatlantic sea-cables, swiss street-cars disabled, another strong geom. Storm on 29.7.	Geom. storm during suncycle minimum measured in France, telegraph disruption in Mexico, Geom. storm reported from East-Asia, in Chicago telegraph lines up to 675 V were measured	more info		
1905	3-2 & 3-3				≈8	≈50° / ≈40°	Chicago & Sioux City (USA)	Electrical disturbances on Chicago- & Sioux City telegraph systems reported		weblink1 (2.3.1905)	-	

1908	9-11				9-	≈45°/≈35°	Washington	disruption of telegraph systems	bright pink-colored (energetic) aurora with streamers, often reaching up to the zenith, observed in Washington	weblink1 (12.9.1908)	-	
1909	9-24/25	-595		probably ≥ X10	9+	≈35°/≈20°	Japan, Maine (USA) (Singapore?)	disruption of telegraph systems in Boston, Chicago, Tennessee and in transatlantic sea-cable reported, disruptions also in telegraph systems in Europe	voltage of up to ≈ 500 V was induced into the telegraph wires, geomagn. disturbance was compared with events from 1803 & 1882 (it was a daytime aurora in Chicago)	more info		
1915	6-17				9-	≈45°/≈35°	Flagstaff (Lowell Obseratory) (Arizona/USA)	eastern telegraph circuits interrupted (USA), only east- & west-cables were effected and these wires were heavily surcharged, electrical disturbances in the western states	bright aurora with streamers observed in Flagstaff, some streamers reached almost to the zenith, was bright for a few hours, aurora reached from 25° west to 45° east	weblink1		
1916	8-25/26				≈7	≤50° / ≤40°	Minneapolis,	telephone & telegraph services in the East & West of the USA were seriously disrupted (between Chicago & Minneapolis), 75 V were induced in the cables	bright night-sky in Minneapolis,	weblink1		
1917	8-8 8-21				9- ≥6	≈50° / ≈40°	Algonquin/Canada	telegraph & telephone communications to Chicago from Pittsburg, Omaha, Buffalo & Philadelphia stopped.	arc aurora with streamers observed in Algonquin/CA on 21.8 telegraph networks around New York area were disrupted too	weblink1	more info	
1918	3-7				9+	≤40°/≤30°	Washington (overhead aurora) Illinois, Tampa/Florida, Texas	telegraph lines from New York to Buffalo were disrupted motors(generators) providing electricity were effected too	bright overhead aurora with streamers observed in Washington and Duluth, another bright aurora on 21.3.1918	more info	weblink1	more info2
1919	1-31 8-11 10-1				9	≤50° / ≤40°	St. Petersburg (overh. Aurora, 31.1.) Denver (11.8.),New York,Omaha (1.10)	telegraph disruptions along Atlantic seaboard as far south as Georgia & Kansas (11.8.), disruption of telegraph systems in Minnesota & NW-states	31.1.: brilliant flaming auroras were observed in the night 11.8.: in Denver aurora visible in northern sky	weblink1		
1920	3-22				9	≤44°/≤34°	New York, Atlanta	disruption of telegraph cables of the American Telegr. Co. Undersea cables were disrupted and stpped working too	flashing and wavering aroras were seen in the northern sky from New York, auroa with streamers seen in Atlanta	weblink1		
1921	5-13 to 5-15	-907 +/- 132			9+	≤34° / ≤24° (north) ≈-33°/ -13° (south)	visible in east-USA, Caribbean, and in Samoa (confirmed !), overhead aurora in California	substantial damage to overhead and underwater telegraph equipment in USA, Europe and in the southern hemisphere, sparked many electrical fires	induced (telluric) ground currents probably were larger than from the 1989 superstorm, Auroras created brightly lit night skies in eastern USA, credible Aurora-report from Samoa	more info	weblink1	
1926	1-26 3-9				9	≈45° / ≈35°	Salzburg/Austria (9.3.)	telegraph systems throughout the country were disrupted all over the country down south to New Orleans (26.1.)	120 to 150 V were induced in telegraph cables (USA)-26.1. bright red aurora visible from Austria/Salzburg	weblink1	-	
1927	2-24 4-14 7-21 10-12				9- (24.2.) ≥7 (12.10)	≈50° / ≈40° (24.2.)	Geneva/Switzerland (24.2.) Berlin (12.10.)	telegraph systems disrupted, Winnipeg to Montreal 14.4. telegraph systems disrupted, New York to Mid-West 21.7. disruption of telegraph networks in northern states 12.10.	bright red aurora visible from Geneva 100 V were induced into telegraph cables 12.10. dissrupted shortwave radio systems to the north, Berlin 12.10. Berlin: glow of Aurora Borealis was visible on 12.10.	weblink1	-	
1928	7-7/8		486		9-	≈45°/≈35°	Sydney, Geelong (Australia)	disruption of telegraph system all over USA caused by earth-currents resulting from the geomagnetic storm	7.July.1928 in Sydney: green&blue auroa with bright white streamers against a red glowing sky visible	weblink1		
1932	5-29/30				9-	≤45°/≤35°	Cleveland, New Mexico, Geneva	radio- & telegraph systems were disrupted by magn. Storm	two wide bands of pale white light appeared in the sky (photo)	more info	weblink1	more info2
1938	1-17 1-22 to 1-25	-336	490/509		8+ 9-	≤ 45°/≈30°	Sicily, Portugal, Bermuda, Southern California	electrical disturbances, short wave radio systems were interfered, 3 geom. Storms, 2 great aurora storms, 4 SSCs	The "Fatima Storm" Jan. 22-25, great Aurora display in Europe, USA & South-Australia, another geom. Storm on 16.4.1938	more info	weblink1	
1941	9-18/19		604		9+	≤ 40°/≈20°	Florida (18.9.), Washington, New Mexico	"geomagnetic flash" reported, disruption of telegraph- & short wave radio systems, another magn. Storm on 6. July	18.09.1941, most brillant aurora display ever seen in Washington (energetic pink aurora), even seen in Florida	weblink1	more info	
1943	8-30/31				8+	≈40°/≈30°	Delaware/Ohio	radio communication between Europe and USA was seriously dissturbed (3.9.)	brilliant aurora during sunspot-minimum visible at Perkens-Observatory/Ohio, aurora with streames covered northern sky	more info	weblink1	
1946	2-7 3-25 & 3-28	-512 (23.3.)	462		8+ 9-	≈40°/≈30° (north & south)	New York (overhead-7.2.),Scottland Canberra 30.3., Cambridge 28.9.	radio disruption reported from Bombay, Lisbon, Cairo & Singapore, & worldwide on 3.2.(until 15.2.) on 26.3.	brilliant waving overhead aurora seen in new York on 7.2. and 26.7. , aurora with bright streamers (colors red & green)	weblink1	more info	more info2
1949	1-25/26 5-12	-530(?)	407 (24.1.)	3+ (1949)	9- 9-	≤45°/≤30°	Adelaide (Australia)-12.5.	complete blackout in India shortwave-radio services, shut-down of radio- & Sea-cable communication on 26.1.	24.01.1949 (-dH-value), sudden-commencement-type Storm 12.5.: bright pink aurora seen from Adelaide	more info	more info2	more info3
1950	2-20 3-19				9- 7+	≤45°/≤35°	Sydney (Australia)	disruption of worldwide radio communication (21.2.1950)	red glowing aurora seen from Sydney in the South on 19. March	weblink1	-	more info3
1956	2-24				8+	≤ 54°/≈35°	one overhead arora visible in South-England	strong solar cosmic rays measured during a strong solar proton event	extremely high ground level (telluric current) enhancement auroras visible on 8 nights (low latitute) in South-England (54°)	weblink1		
1957	1-21/22 9-13		486 (13.9.)		9- 9-	≤ 54°/≈35°	South-England (13.9.), France (23.1.) Chicago (4.9.), Los Angeles (13.9.)	stong solar storms measured (13.9.), spectacular fade-out of radio signals worldwide (16.4.)	highest auroral activity for at least two centuries (NASA) auroras visible on 30 nights (low latitute) in South-England (54°)	weblink1		
1958	2-11	-425	617/472		9	≤ 45°/≈23°	Havana,Los Angeles,New Mexico Washington, across Europe	strong geomagn. storm, most communication systems were disrupted for a few hours, blackout in Toronto, SSC	telegraph cables over the North Atlantic became a 2650V battery, auroras visible on 16 nights in South-England (54°)	more info	weblink1	
1960	11-12/13		417		9+	≤40°/≤30°	Western Europe, Atlantic overhead in France	widesread radio disruption	12.11.1960 (-dH-value), active arc aurora with streamers, sometimes brilliant red flaming curtains	weblink1	more info	
1967	5-25/26		509		9	≤45°/≤35°	England, Northern France, W-Atlantic, Washington	strong geomagnetic storm measured	25.5.1967 (-dH-value), brilliant aurora bands with streamers colored in red, violet & green	more info	more info2	weblink1

1969	3-24				8	≈45°/≈30°	Eastern USA, New York to Louisiana		mostly red aurora with green and yellow colors	weblink1		
1972	8-4	-450 to -486		X20	9	≤45°/≤35°	Illinois to Colorado Bilbao/Spain	disruption of electrical- & communication networks & satellites, DST-value may have surpassed -1600 nT	series of strong solar flares (peak class 20), fastest CME-transit ever recorded, 4 X-flares, strong geom. Induced currents (GICs)	weblink1		
1974	7-5/6				9-	≤50° / ≤40°	Chicago, Ohio, Michigan, Omaha	strong geomagnetic storm measured	brilliant green- & yellow-colored aurora was visible over Chicago	more info	more info2	weblink1
1982	7-13/14	-330	630	3B/X7.1	**9**	≤45°/≤35°	Bermuda, Sardinia, Malta, Australia Michigan, Ontario, Atlantic, UK	the geom. storm from 13.7. produced a localized (around Japan) short-lived (1.5h) deep depression of geom. H-comp.	13.7.1982 (-dH-value), aurora borealis observed in the Mediterranean region	more info	more info2	
1989	3-13/14	-589	644	X8	**9+**	≤ 40°/≈20°	Florida, Honduras, Caribbean Wales: overhead aurora	caused the collapse of the Hydro-Quebec Power grid in seconds (protection relays tripped in a cascade), widespread effects on power systems	on 13. March the strongest geom. Storm of the last century struck Earth with intense auroras ,(-dH-value: date : 13.3.), another X4.5-flare was caused 2 days earlier,10. March 89)	more info		
1991	3-24/25 6-5 11-8/9		503		9- 9- 9-	≤45°/≤30°	Texas, Pennsylvania, California (9.11) Graz (Hungary)-24.3.	around half of the energy output of the 1989 event, worst mag. Storm since 1989	24.3.91 (-dH-value), in Northern USA aurora covered whole sky active flaming pulsting aurora seen in Graz (24.3.)	more info	weblink1	
1992	5-9/10		426		9-	≤55°/≤45°	North Dakota, south. Scotland		9.5.1992 (-dH-value), aurora with bright streamers	more info		
1995	4- 7/8 (10- 18/20)				8 7-	≈50° / ≈40°	Denmark, Northern England & Detroit (18/19.10.);North Dakota, Scotland & Midlands in UK (7.4.)		brightest aurora seen all over the sky in North Dakota 7.4. and all over Scotland down to the english midlands	more info		
1996	10-22/23				7+	≈50° / ≈40°	North Dakota		23.10.1996 - Ap-Index 38 & Kp-max=7+ active moving, waving & pulsating Aurora observed in Dakota	more info	more info2	
1998	5-4 9-25	-216 (soho) -207 (soho)			9- 8+	≤50° / ≤40°	Chicago, Detroit, Boston (4.5.) Dakota (USA) in Sept./Oct.		active moving, waving & pulsating Aurora observed in Dakota	more info	more info2	more info3
1999	10-22	-237 (soho)			8	≈50° / ≈40°				more info	weblink3	
2000	4-6/7 7-15 8-11/12 9-17	-321 (soho) -301 -237 (soho) -201 (soho)		X5.7 (14.7.)	9- **9** 8- 8+	≤45°/≤35°		minor satellite- & power transformer damage worldwide associated solar particle event was 4.th largest since 1967 (15.7.2000)	DST-value from 14/15. July, G5-storm, "Bastille Day storm°	more info	more info2	weblink1
2001	3-31 4-11	-377 (soho) -251 (soho)	477		9- 8+	≤45°/≤30°	Texas, California, Florida	fast moing CME triggered vivid aurora in Nov. 2001	red aurora visible on 6. April was caused by X20 flare, but the majority of the solar storm missed the Earth	more info		
2003	10-29 to 11-2	-353 I -383	423		**9**	≤45°/≤30°	Texas, Mediterranean countries, (South Africa?)	3 strong geom. Storms from 29.10--2.11 ->"Halloween Storm" 12 transformers in South Africa were disabled by the storm	3 geom. Storms between 29.10 and 2.11. overlapped each other DST-values : -151, -353 & -383, storm of a X45 flare missed Earth	more info	weblink1	
2003	11-20	-533	415 (20.11.)		9-	≤40°/≤25°	Florida, South Australia	extreme radio blackout was caused on 4. Nov. 2003	on 4th of Nov. a powerful X34 flare was detected	weblink1	weblink3	
2004	7-25/26 11-4 to 11-10		460 (7.11.)		8 9-	≤45°/≤35° (25.7.)	25.7.: Michigan, California, New York 7.11.: Alabama, Ohio			weblink1		
2005	5-15		401 (15.5.)		8+	(GFZ-Potsdam data)		big solar storm caused large-scale atmospheric ionization	20. Jan 05			
2013	3-17				7-	(GFZ-Potsdam data)						
2013	6-1				7	(GFZ-Potsdam data)						
2013	10-2				8-	(GFZ-Potsdam data)						
2014	2-19				6+	(GFZ-Potsdam data)						
2015	3-17				8-	(GFZ-Potsdam data)		St. Patrick's Day storm:				
2017	9-8			X8.2	8+	(GFZ-Potsdam data)						
2022	2-3			M1.1	5	(GFZ-Potsdam data)		CME ended up as shock-driving magnetic cloud (MC)	3. February: 39 starlink satellites lost in solar-storm	more info		
2022	9-30				4	(GFZ-Potsdam data)	Tasmania	bright aurora visible in Tasmania		more info		
2023	2-10/11			X1.1	4	(GFZ-Potsdam data)		temprary radio blackout in South America		more info		
2023	2-16/17			X2.2	5	(GFZ-Potsdam data)	New York, Idaho (predicted)	temporary radio blackout on sunlit side of Earth		more info		
2023	2-27				7-	(GFZ-Potsdam data)						
2023	3-3			X2.1	4	(GFZ-Potsdam data)		caused a shortwave radio blackout in N- & S-America		more info		
2023	3-24				8	(GFZ-Potsdam data)		see GFZ-data table - Appendix 6-B				
2023	4-23/24				8+	(GFZ-Potsdam data)	South Australia,NSW & WA		24. April : bright Aurora visible across southern Australia	more info		

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Please also read my Study-Part-2 : **Changes in Earths Magnetic Field are a main cause of Volcanism, Earthquakes, HGFA-seismicity & Global Warming**

& Study-Part-1 : **The cause of El Ninos is increased hydrothermal-activity in defined submarine areas – An aperiodic global phenomenon !**

Part 1e : **→ Extened version of Part 1 including Chapter C4**

& Study-Part-4 : (→ will be published soon)

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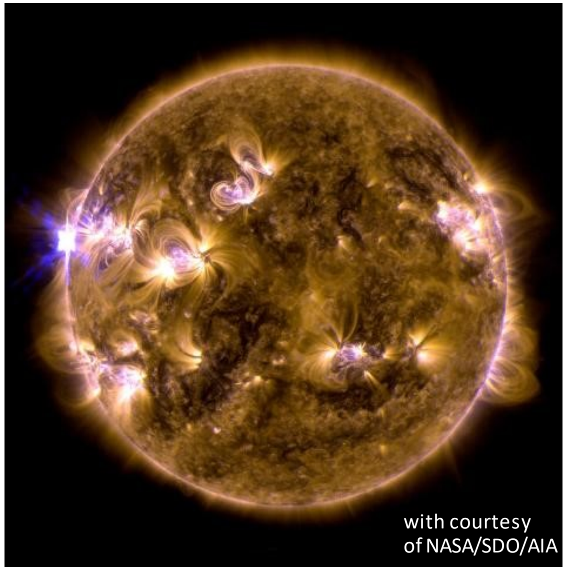
the Sun



the **X 1.7-class** **Solar flare** from **12th May 2013**
→ the bright point on the left side of the Sun